INTERAVIA

REVIEW OF WORLD AVIATION

Price of this Issue —

U. S. A.:	80 cents
British Isles:	3/6
Switzerland:	Fr. 2.80
Netherlands:	Fl. 2.50
Denmark:	Cr. 5.-
Germany:	DM 2.75
France:	Fr. 250
Italy:	Lire 410
Japan:	U.S.$ 0.80
Sweden:	Cr. 3.50

IN THIS ISSUE

Policing the Skyways

Spotlights on American Industry

VOLUME XII 6 JUNE 1957

THE AVRO ARROW
The name selected for the still secret AVRO CF-105 is symbolic of the pointed missile concept of this supersonic interceptor, being developed as the successor to the AVRO CF-100.
AVRO
AIRCRAFT
AVRO AIRCRAFT LIMITED
MALTON, CANADA

INTERAVIA

Review of World Aviation

Volume XII **No. 6** **June 1957**

Contents

POLICING THE SKYWAYS

The Bottleneck : Air Traffic Control . . . . . A. FISCHER, ZURICH **549**
TACAN Combines Accurate Navigation with Strict Airspace Control **553**
Barrack Square Discipline over the North Atlantic **561**
An Automatic Landing System **563**
Radar for Air Traffic Control and Navigation **564**
Buying Time . . . . . C. CORDDRY, WASHINGTON **566**
False Start Makes a Winner **573**
Inertial Navigation . . . N. F. PARKER & C. P. GREENING, DOWNEY **575**
Argus Eyes and Electronic Brains Protect the North American Continent . . . . . K. BOLLIGER, DÜBENDORF **578**
Lockheed's Silver Jubilee **582**
General Dynamics Reports Record Results—but Loses its Founder . **584**
What's in the Air ? **586**
We "IATAns" are the First World Citizens W. DESWARTE, BRUSSELS **593**
Aviation Traders ATL. 90 Accountant **594**
The White Paper on Defence — A British View D. H. WOOD, LONDON **597**
Equipment Round-Up **598**
Two Years after the Restoration of Air Sovereignty W. EBERHARD, BONN **600**
The Need for Automatic Air Traffic Control Systems A. MARTIENSSEN, HENGELO **601**
New York Finance Notes . . . . . S. HERSHEY, NEW YORK **531**
The Mind of Mr. Reader **532**
Conferences and Exhibitions **532**

Front cover :

TACAN ground station built by Federal Telecommunication Laboratories, amidst the Alaskan mid-summer landscape.

Editor-in-Chief :
E. E. Heiman

Executive Editors :
H. Rieck, E. Herzfeld

Associate Editors :
J. M. Stroud, H. Lapierre, E. Baur, P. Hausheer, K. Regelin, A. Arbex, E. Naschke

Art Editors : H. W. Mahrer, O. Fischer
Advertising : P. Russak
Circulation : G. Deneke

OFFICES : Paris : Georges Février (Manager) ; **London :** Derek Wood (London Editor) ; **Rome :** Giorgio Lourier (Manager) ; **Bonn/Rhein :** Wolf Eberhard (Manager) ; **Washington :** Harry Tennant (Editorial Director U.S.A.).

CORRESPONDENTS : Amsterdam : Henk A. Jansen ; **Antwerp :** Roger F. J. Gillyns ; **Athens :** Manos Pavlidis ; **Bombay :** K. K. Anchan ; **Copenhagen :** Kay Nielsen ; **Johannesburg :** J.K. Chilwell ; **Linköping :** Sven Walberg ; **Los Angeles :** Norman Lynn ; **Madrid :** Luis Saenz de Pazos ; **Mexico City :** José Villela, Jr. ; **New York :** James Winchester ; **Rio de Janeiro :** Basil de Kanel ; **Tokyo :** N. Matsumura ; **Toronto :** M. Willmot ; **Vienna :** (and South East Europe) : Max W. Morstadt.

Agents :

Interavia Belgium 5, Heidestraat Noord, Cappellenbosch-lez-Anvers
Interavia Canada 25, Farmcote Rd., Don Mills, Ont.
Interavia France 144, Avenue des Champs-Elysées, Paris 8me
Interavia Germany Interavia Verlags-G.m.b.H., Koblenzer Str. 68, Bonn/Rhein
Interavia Great Britain 14, Clarges St., London, W.1
Interavia Holland Henk A. Jansen, Olympiaplein 84, Amsterdam-Z
Interavia India No. 2 Gandhigram Rd., Juhu, Bombay
Interavia Italy 30, Via San Marino, Rome 7.23
Interavia Japan Isogo P.O. Box 3, Yokohama
Interavia Mexico Ave. de los Alpes 1030-6, Lomas de Chapultepec, Mexico 10, D.F.
Interavia South Africa P.O. Box 10242, Johannesburg
Interavia South East Europe Postfach 192, Vienna I./1
Interavia Spain Donoso Cortés 83, Madrid
Interavia Sweden P.O. Box 29, Linköping
Interavia U.S.A. 185, Madison Ave., New York 16, N.Y.
803 National Press Building, Washington 4, D.C.

Distributors :

Austria Morawa & Co., Wollzeile 11, Vienna I
Canada Wm. Dawson Subscription Service Ltd., 587 Mount Pleasant Road, Toronto 12, Ont.
Edward Company Regd., P.O. Box 98, Station Delorimier, Montreal P.Q.
Finland Akateeminen Kirjakauppa, Keskuskatu 2, Helsinki
Rautatiekirjakauppa Oy, Köjdenpunojank 2, Helsinki
Germany W. E. Saarbach G.m.b.H., Gertrudenstrasse 36, Cologne
Great Britain W. H. Smith & Son, Ltd., Strand House, Portugal Street, London, W.C. 2
Wymans Ltd., New Street Square, London, E.C. 4
Ireland Basil Clancy, Cooleevin, Foxrock, Co. Dublin
Japan Maruzen Co. Ltd., 6 Tori-Nichome Nihonbashi, Tokyo
Norway Narvesens Kioskkompani A.S., Box 125, Oslo
Uruguay Humanitas, Colonia 883, Montevideo

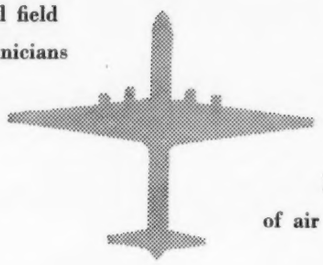
Advertising Department : Publishing and Editorial Offices, Subscription Department : Interavia S.A., 6, Corraterie, Geneva. Telephone : 25 42 34 (five lines). Cables and Telegrams : Interavia-Geneva. Teleprinter : 22 122. Postal Cheque Account : Geneva I 5380.

Annual Subscriptions : U.S.A. and Canada, U.S. $7.00 ; United Kingdom and Eire, £2.2.0 ; Commonwealth, £2.6.0 ; Switzerland, 28.— fr. ; Austria, 170.— sch. ; Belgium, 320.— fr. ; Denmark, 48.— kr. ; France, 2400.— fr. ; Germany, 27.50 DM ; Holland, 25.— fl. ; Italy, 4060.— L. it. ; Japan, U.S.$7.00 ; Latin American countries, U.S. $7.00 ; Norway, 50.— kr. ; Spain, 280.— pts. ; Sweden, 35.— kr. All other countries, 28.— Sw. fr.

Appears Monthly in Four Editions : English, French, Spanish and German.

Copyright 1957 by Interavia S.A., Geneva, Switzerland

Each special field has its technicians



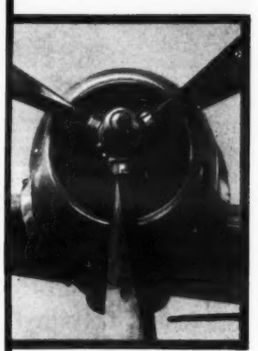
In the matter of air transport the

"Africa" field

implies the participation of the

technician UAT

Does your business require your presence in French West Africa, the Cameroons, French Equatorial Africa, Rhodesia or South Africa ?



One of U.A.T.'s Super DC-6s will take you there in the minimum time, with the maximum comfort and convenience.

Used by more than 60 % of air travellers because of its comfort standards, the DC-6 holds the world record for regularity of service.

When you think of
AIR TRANSPORT
+ AFRICA
remember to say
THE SPECIALIST
U.A.T.

JEP & CARRÉ

U.A.T

AEROMARITIME

3, Bd Malesherbes — Paris 8e
Tel. Anjou 78.04 to 09

information and tickets
from all accredited travel agents

This electrical tape handles the toughest insulating jobs!

Famous "SCOTCH" Brand No. 33 Electrical Tape is the all around "workhorse" of electrical insulating: from exposed magneto cables (where it is subject to all the blast, temperature changes, and dirt of the open nacelle), to such sheltered applications as radio lead insulating, "SCOTCH" No. 33 offers maximum protection with minimum application. It is made with a polyvinyl plastic backing, is thin, tough, stretchy; sticks at a touch; conforms easily to curves and contours. For complete information, write 3M Company nearest you (listed below), or direct to: 3M Company, St. Paul 6, Minnesota, U.S.A.

BETTER PRODUCTS
WORLDWIDE
THROUGH RESEARCH

SCOTCH BRAND ELECTRICAL TAPE

RADIO transmitter and receiver cables being wrapped with "SCOTCH" No. 33 Electrical Tape. High dielectric strength of 9500 volts gives maximum insulation with minimum tape bulk and weight.

FUEL INJECTION tubing being wrapped with "SCOTCH" No. 33. It resists alcohols, oils, solvents; protects tubing from abrasion and corrosion; won't wear out; won't pull loose.

GENERATOR LEADS on a radial engine being taped with "SCOTCH" Brand No. 33 Electrical Tape. High resistance to moisture and temperature change assures long life of trouble-free service.

A product of 3M Research

3M COMPANY

3M MANUFACTURING PLANTS IN:

ARGENTINA . . . Fábrica Argentina de Materiales Adhesivos, Belgiano 1724, Buenos Aires.

MEXICO . . . Minnesota Manufacturera de México, Apartado Postal 7533, México City 1, D.F.

BRAZIL . . . Minnesota Manufatureira e Mercantil, Ltda., Caixa Postal 123, Campinas, Est. São Paulo.

ENGLAND . . . Minnesota Mining & Mfg. Co., Ltd., Arden Road, Adderley Park, Birmingham 8.

FRANCE . . . Minnesota de France, 135 Boulevard Serurier, Paris 19me.

GERMANY . . . Minnesota Mining & Mfg. Co. m.b.H., Immermannstrasse 40, Düsseldorf.

AUSTRALIA . . . Minnesota Mining and Manufacturing (Australia) Pty., Limited, St. Marys, New South Wales.

CANADA . . . Minnesota Mining and Manufacturing of Canada, Ltd., P.O. 757, London, Ontario.

How to get TOMORROW'S speed from TODAY'S runways...

ALLISON PROP-JET POWER

The matched team of Allison Model 501 Prop-Jet engines and Aeroproducts Turbo Propellers is the most advanced aircraft power of its type available anywhere in the world today... backed by over 11½ million hours of turbine flight time!

The efficiency of the Aeroproducts Propellers allows take-offs and landings in existing fields, with runway to spare — thus bringing jet-age speed and luxury to the 200-to-500 mile flights which comprise most air travel. Its 30% greater fuel economy makes Allison Prop-Jet power ideal for longer flights, too — up to 2500 miles non-stop!

Weight saved in four Allison engines equals the weight of 52 passengers — **plus baggage!** Each Allison 501 delivers 2.1 h. p. per pound — a better power-to-weight ratio than you'll find in any other prop-jet available today!

Proven performance and economy have made Allison the logical choice to power new fleets of Lockheed Electras for such leading airlines as: KLM Royal Dutch, Braniff International, American, Eastern, National and Western.

ALLISON PROP-JET POWER

... backed by the worldwide resources of

GM
GENERAL MOTORS

Through these portals pass the most-traveled people in the world!

Since the day sands first shifted under the whirring beat of an aeroplane propeller, the world has become full of air-minded people.

Today, it requires but a few short hours to span the broad sweep of the world's continents and oceans.

Today, almost 8,000 airline flights are scheduled daily—and other thousands of commercial aircraft stand ready to give swift and sure transportation of men and materials to any point of the compass — bringing cities, people and businesses closer together than ever before in history.

Today, throughout the world, more of these vital aircraft rely on Goodyear tires, wheels and brakes than on any other make.

Goodyear Aviation Products have been serving aviation progress since 1909. They have done a singularly outstanding job of it.

GOODYEAR

AVIATION PRODUCTS

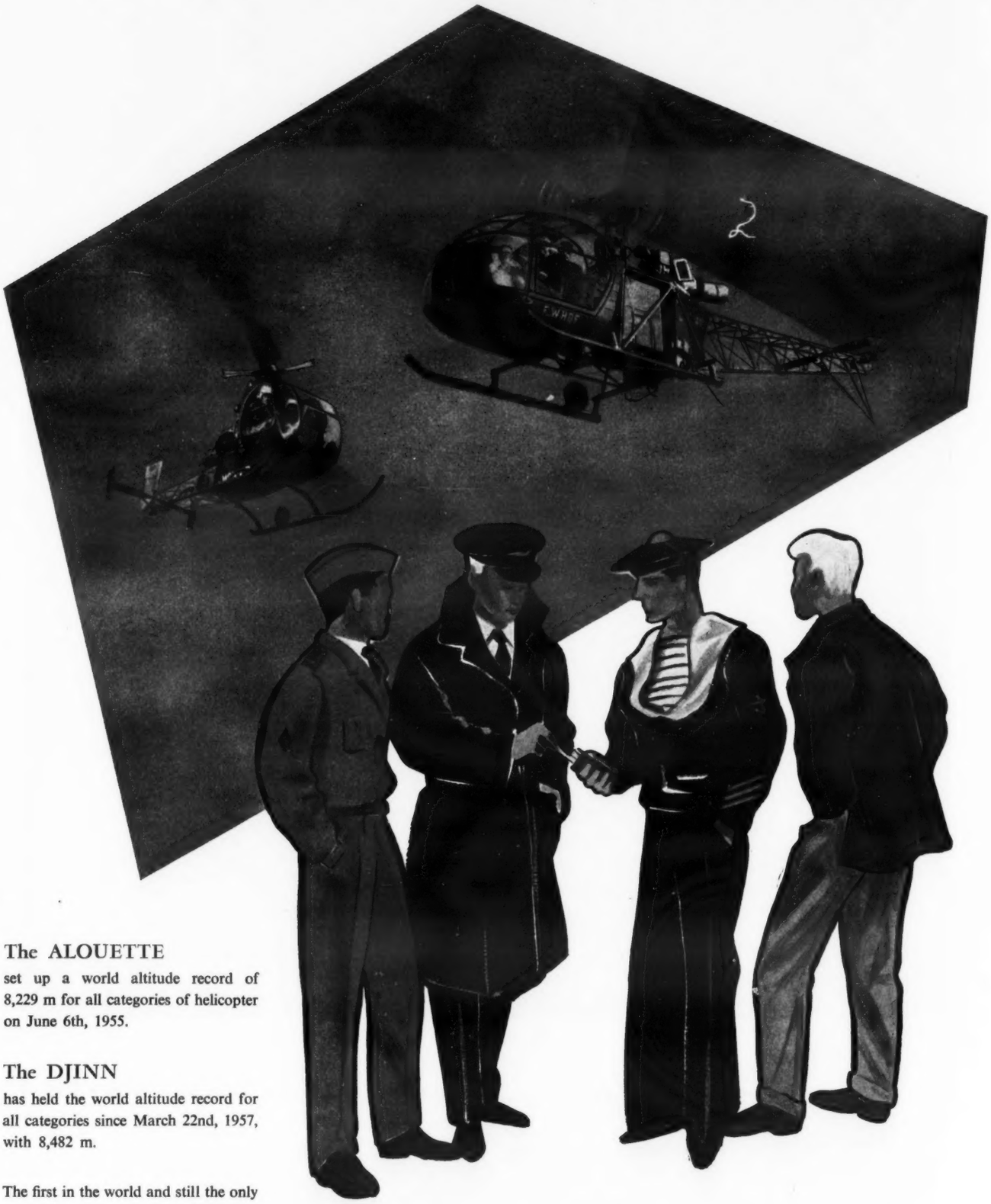
Producers of aircraft tires, wheels, brakes, fuel cells, fuel systems, automatic ice protection and other products for commercial, military and private aviation. Goodyear International Corporation, Aviation Products Dept., Akron 16, Ohio, U.S.A., or The Goodyear Tyre & Rubber Company (Great Britain) Ltd., Wolverhampton, England.

Fly *Friendship*— and SEE the world!

The standard version "Friendship" will carry 32 passengers in a spacious cabin with modern design features such as pressurisation, low sound level and unique visibility for all passengers.

Fokker

All civil and military applications



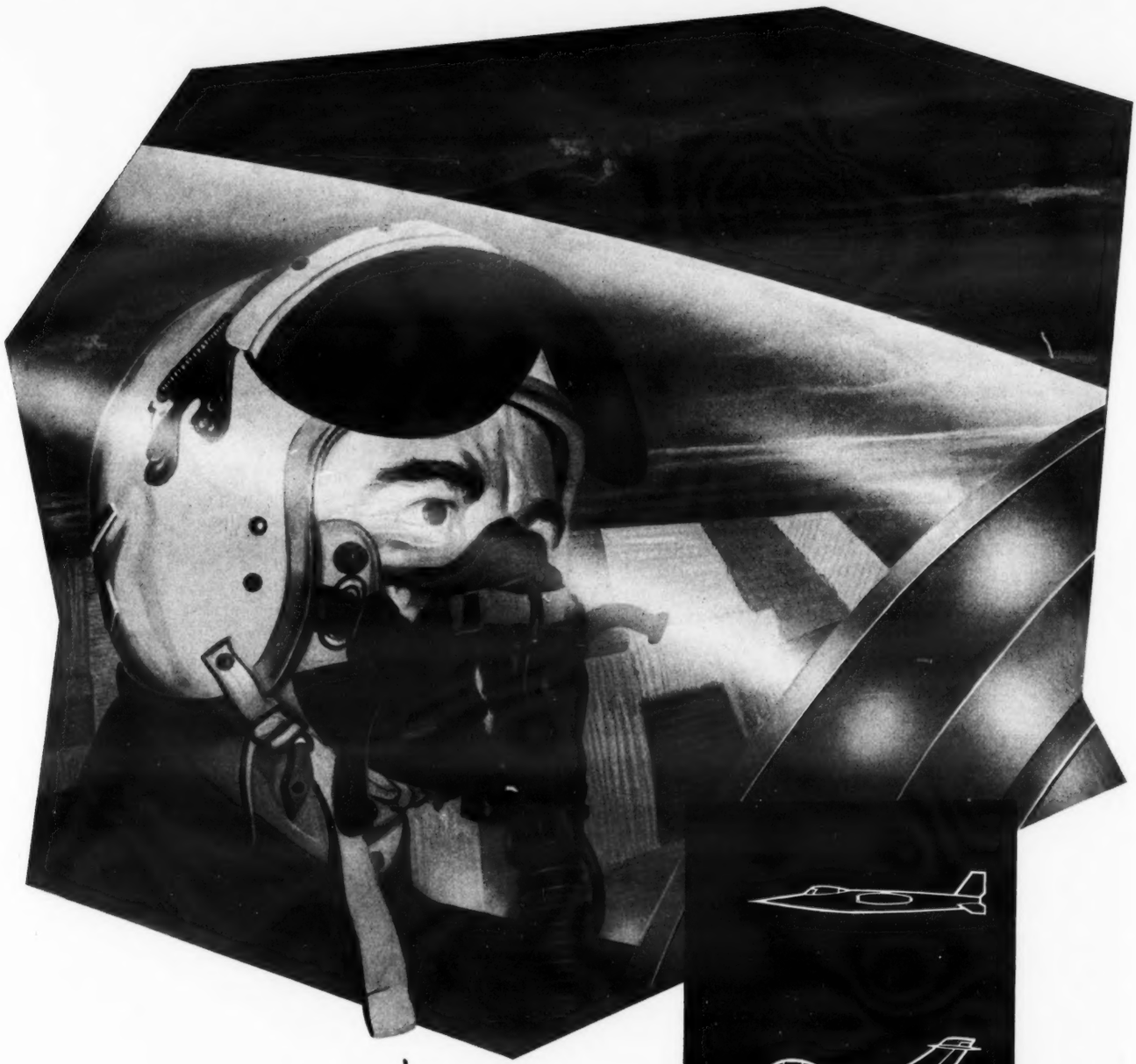
The ALOUETTE
set up a world altitude record of 8,229 m for all categories of helicopter on June 6th, 1955.

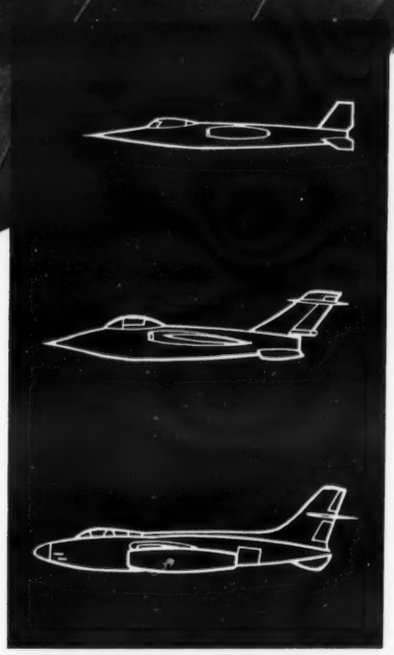
The DJINN
has held the world altitude record for all categories since March 22nd, 1957, with 8,482 m.

The first in the world and still the only 2 turbine-powered helicopters produced in quantity. The ALOUETTE and the DJINN supplement each other and together cover the full range of civil and military needs.

SUD-AVIATION

Head Office: 37 Bd de Montmorency, Paris XVI[e]





THE TRIDENT II

light interceptor, an experimental batch of which has been ordered, will exceed twice the speed of sound and can use hastily prepared airfields. It is armed with an air-to-air missile carried beneath the fuselage.

THE BAROUDEUR

single-seat tactical support aircraft, powerfully armed and highly manœuvrable, takes off, lands and manœuvres on skids on all terrains.

THE VAUTOUR

twin-jet combat aircraft ordered in large numbers by the French Air Force, in its 3 versions — all-weather fighter, ground attack and bomber.

SUD-AVIATION

SOCIÉTÉ NATIONALE DE CONSTRUCTIONS AÉRONAUTIQUES

Head office: 37, Boulevard de Montmorency — PARIS 16e

Silence and perfect comfort

CARAVELLE

Silence

CARAVELLE, like all jet aircraft, has no vibrations. Moreover, thanks to the position of its engines at the rear of the fuselage, it gives its passengers complete silence. Quieter than the most luxurious of automobiles, the CARAVELLE's cabin demonstrates our engineers' achievements. Measured noise level: *82 decibels.*

Comfort

CARAVELLE is not only quieter and faster, but also more comfortable. The same quiet atmosphere prevails throughout the CARAVELLE's cabin, from the first row of seats to the last. *No bad seats.*

PARIS
Head office:
37 Bd de Montmorency

SUD-AVIATION

NEW YORK
500, Fifth Avenue

INTERAVIA

Deadline Notes

No. 6, 1957

● **British Overseas Airways Corporation** has concluded, after much consideration of its aircraft requirements for the African, Far Eastern and Australian services from the mid-1960s onwards, that its needs will best be met by a new advanced project offered by Vickers-Armstrongs (Aircraft) Ltd. This aircraft, at present designated the VC.10, is to be a medium-long range turbojet model powered by four Rolls-Royce *Conway* engines. The Corporation's version will have seats for up to 120 passengers. Other features : particularly good take-off performance at high level and high temperature airfields, a cruising speed competitive with that of other jet aircraft operating in the mid-1960s, double-bubble fuselage similar in appearance to that of the turboprop Vickers *Vanguard,* and capacious freight holds. The VC.10 project is being developed by Vickers as a private venture. — B.O.A.C. and Vickers are jointly engaged in preparing the detailed specifications and conditions of contract, and the Corporation has indicated that when this task has been completed it intends to place an order for 35 VC.10s for delivery beginning in 1963. The value of the order will be about £68,000,000, including the cost of initial spares.

● **Central African Airways** has been authorized to enter into an agreement with British Overseas Airways Corporation whereby B.O.A.C. will take over C.A.A.'s overseas routes. The agreement will remain in force for ten years from July 1st, 1957, but may be suspended in the event of B.O.A.C. not being able for any reason to provide services in accordance with obligations. B.O.A.C. will operate services between the Federation of Rhodesia and Nyasaland and the United Kingdom on behalf of C.A.A., initially using *Argonauts,* which, however, will be replaced by *Britannias* as soon as possible. The aircraft will fly under B.O.A.C. markings and will be manned by B.O.A.C. crews. C.A.A. has been guaranteed a minimum profit of £1,750,000 over the ten years covered by the agreement.

● **Union Aéromaritime de Transport** carried nearly 10,000 tonnes of cargo between France and Africa in 1956, an increase of approximately 15 % over 1955. Whereas five years ago most of the items carried were perishable, today it is mostly machinery that is being transported by air. In line with this trend, the company acquired five Nord 2502 *Noratlas* transports in 1954, and a fifth in 1956. Satisfactory results were recorded for the DC-4 cargo services operated to French territories in Africa and to Rhodesia and South Africa. The combined sea-air services organized by the company are also flourishing. For a long time, the inadequate volume of freight available for transport from Africa to France caused concern to all operators serving Africa. Lately, however, return traffic has shown a substantial increase as a result of the gradual development of African economy.

● **Sabena** is now operating Douglas DC-7Cs on its Brussels-Geneva-Leopoldville route. No intermediate landing is now made at Tripoli, and the Geneva-Leopoldville leg is flown non-stop. Flying time has been cut from 15 hours (by DC-6) to 12 hours 30 minutes. — Introduction of the DC-7C on the route was made possible by the extension of the runway at Geneva-Cointrin Airport from 6,560 ft. to 8,530 ft. The main runway at Cointrin is to be lengthened to a total of 12,800 ft. by 1960.

● **Sabena** has placed an order with Royal Netherlands Aircraft Factories Fokker for twelve F.27 *Friendships.*

● **The SE.210 Caravelle** is the first (and so far the only) jet transport to be granted permission by the Port of New York Authority to use Idlewild International Airport.

● **Interest in the SE.210 Caravelle** is being shown by Sabena, Scandinavian Airlines System and Trans-Australian Airlines. Sabena is expected to make a decision (probably a favourable one) shortly on the purchase of the French medium-range jet transport, according to reports from Brussels.

● **Pan American World Airways** has been running four flights a week on its de-luxe "President Special" services between New York City and London since June 1st. Services leave New York on Mondays, Wednesdays, Fridays and Saturdays and cost an extra $50 premium fare.

● **The Mexican Directorate General of Civil Aviation** has issued the following new operating permits for services to be run under the terms of the air agreement recently concluded with the United States : 1. *Aeronaves de México S.A. :* Mexico City-Washington-New York ; Mexico City-New Orleans. Lockheed *Super Constellation.* — 2. *Cia Mexicana de Aviación S.A. :* Mexico City-Chicago ; Mexico City-San Antonio, Texas. Douglas DC-7C. The following operating licences are also confirmed : 1. *Guest Aerovias México S.A. :* Mexico City-Miami ; Mexico City-Windsor, Canada. Lockheed *Super Constellation.* 2. *Cia Mexicana de Aviación S.A. :* Mexico City-Los Angeles. Douglas DC-7C.

● **Aerovias Venezolanes S.A.,** a private Venezuelan airline, has obtained a $1,200,000 credit from the Export-Import Bank of Washington to finance the purchase of five F-27 turboprop transports from Fairchild Engine & Airplane Corporation. The aircraft will be delivered to AVENSA in April, May, June, September and October, 1958. The credit will be repayable in ten equal semi-annual payments.

● **Real Aerovias S.A.** has ordered three 1049H *Super Constellations* worth $9,000,000 from Lockheed Aircraft Corporation. The aircraft, which are scheduled for delivery from December this year, will be used on the company's Buenos Aires-Chicago route.

● **Air India International** plans to use its first three Boeing 707s over the India-London and India-Australia routes, and not across the Atlantic, according to reports from Bombay. Expansion plans across the North Atlantic and Pacific have been shelved for the time being in view of the shortage of aircrew.

● **North American Aviation** has been awarded a design study contract by the U.S. Air Force for a new long-range interceptor which officials expect to attain a speed of at least 2,000 m.p.h. Although no details have been given, it is indicated that the aircraft might have a range of 2,000 miles. — Earlier efforts to get a new long-range interceptor for Continental Air Defense Command were dropped a year ago, chiefly because of lack of money. The Air Force at the time cancelled development contracts with Northrop Aircraft Inc. and North American Aviation.

● **Lockheed Aircraft Corporation's** deliveries of commercial airliners this year will total $200,000,000, according to Robert E. Gross, Chairman of the company. It will be the highest figure in the firm's history, the previous record, set up in 1955, having been just under $132,000,000. *Super Constellations* and the 1649 *Starliner* make up the bulk of the commercial orders to be filled in 1957. Large-scale deliveries of F-104 *Starfighters* to the Air Force and T2V-1*SeaStar* jet trainers are also scheduled.

● **Lear Inc.** is one of the leading subcontractors for the Boeing *Bomarc* interceptor missile. According to A. F. Haiduck, Executive Vice-President of Lear, the Grand Rapids, Mich. Division and LearCal Division are supplying airborne electronic components that control and direct the missile to its target.

● **Armstrong-Siddeley Motors Ltd.,** Coventry, England, and The Garrett Corporation, of Los Angeles, Calif., have concluded a licence agreement covering the manufacturing and sales rights in Britain of the auxiliary power gas turbines and air turbine starters developed by the AiResearch Manufacturing Division. The agreement will be ratified with the approval of the respective Governments.

● **Société Morane-Saulnier** announces a contract from the Argentine authorities for delivery of 48 MS.760 *Paris* twin-jet communications aircraft, to a value of 2,500,000,000 French francs. The aircraft will be shipped to Argentina in parts for assembly at the Industrías Aeronáuticas Mecánicas plant at Córdoba. Two technical experts from Société Morane-Saulnier will shortly leave for Córdoba to assist in the preparations. Delivery of the aircraft will take place between March 1958 and March 1960.

● **S.A.B.C.A.** (Société Anonyme Belge de Constructions Aéronautiques) is to produce some of the parts for the F.27 *Friendship* transports for Sabena and the Belgian Air Force. S.A.B.C.A. will also participate in production of the *Caravelle* if the latter is ordered for Sabena. An agreement to this effect exists between S.A.B.C.A. and Sud-Aviation.

● **A Franco-German Research Institute** is the subject of a proposal before the West German Bundestag. The plan calls for the transformation of the St. Louis armaments research establishment, which is under French management but employs a number of German experts, into an institute jointly managed by the two countries, to be known as St. Louis/Weil am Rhein Research Institute. The establishment would be financed in equal parts by the Governments of France and the German Federal Republic.

● **Lieutenant General Thomas S. Power,** Chief of the Air Research and Development Command, has been appointed by President Eisenhower to head the Strategic Air Command with the rank of full General. He will succeed General Curtis E. LeMay, who will become Vice Chief of Staff of the Air Force this summer. Lieutenant General Samuel E. Anderson will in turn replace Power as A.R.D.C. Chief. — Lieutenant General Frank F. Everest, Deputy Chief of Staff, Operations, has been named to succeed Lieutenant General William H. Tunner as Commander of U.S. Air Forces in Europe, also with the rank of full General. Tunner replaces General Everest in his Pentagon post.

● **The United States** has resumed the shipment of military supplies to Yugoslavia. Deliveries under the Military Aid Program were suspended last autumn when fears arose in the United States that Yugoslavia might rejoin the Soviet bloc.

● **The West German Defence Ministry** was reorganized as follows with effect from June 1st: Military Departments Nos. IV to VII assumed the name of Führungsstäbe (command staffs). Department No. IV is now Command Staff of the Armed Forces (Führungsstab der Bundeswehr); V is Command Staff of the Army (Führungsstab des Heeres); VI Command Staff of the Air Force (Führungsstab der Luftwaffe); VII Command Staff of the Navy (Führungsstab der Marine). The previous heads of the various departments are now known as Inspectors. A new inspectorate for the medical and health services has been set up, as well as a territorial defence directorate. The latter unites the divisions of Departments IV and V which are responsible for home defence.

● **The Royal Navy's D.H.110 Sea Vixen** fighters are to be equipped with the *Firestreak* air-to-air guided missile developed by de Havilland. — Both the Gloster *Javelin* and the English Electric P.1 are already so equipped.

● **The Belgian Air Force** is planning to order six Fokker F.27 *Friendships.*

Workshop Briefs

• Continuing its efforts to reduce the seat-mile costs of the *Comet 4A* jet commercial transport still further, de Havilland has designed a new version, the 4B, for medium-range operations. Seating capacity has been increased by 10%, and seat-mile costs reduced by roughly 15%.

• Grumman Aircraft has won a design contest for an observation aircraft to be used by the U.S. Army and U.S. Marine Corps. Powerplant chosen for the projected aircraft is the Lycoming T53 propeller turbine.

• A new turbojet, the TJ38 with a static thrust of 12,500 lbs. and extremely low noise level, has been developed jointly by Curtiss-Wright Corporation and Bristol Aeroplane Company.

• Boeing Airplane Company confirms that it has received a provisional contract valued at $7,109,915 for production of an undisclosed number of Boeing IM-99 *Bomarc* surface-to-air missiles.

• The Chance Vought F8U-3 *Crusader* and Douglas A4D-3 have now reached the production stage.

• Four versions of the Fokker F.27 are to be built:—*Friendship* standard commercial transport version; *Troopship* troop transport; *Freightship* combined cargo and passenger version; and *Friendship-de-Luxe* executive version.

• Fairey *Gannet A.E.W.3* is the designation of a new version of the *Gannet* to be used primarily for early warning purposes.

• The Westland *Wessex* turbine-powered helicopter has begun flight testing. The *Wessex,* ordered for the Royal Navy, will be used first and foremost for anti-submarine and sea rescue duties.

• New high-performance jet engines designed by American manufacturer are mentioned for the first time: Pratt & Whitney J58 of at least 22,500 lbs. static thrust;—Allison J89 of over 25,000 lbs. thrust.

• The Volscan air traffic control aid, originally for military use, is undergoing C.A.A. tests for possible civil use.

• The Missile and Ordnance System Department of General Electric Company announces the production of special arms containers, which can be easily mounted on helicopters. The arms proposed are 0.308 calibre machine guns and small rockets.

• Exact figures for the English Electric P.1 fighter's main dimensions have been revealed for the first time: span 34 ft. 10 ins., length 49 ft. 8 ins., height 17 ft. 3 ins., span of horizontal tailplane 14 ft. 6 ins.

• "All-steel" ATAR engines are being developed by SNECMA, France, to meet the conditions imposed by the constantly increasing speeds of future combat aircraft. These models will be capable of operating at flying speeds of Mach 2.5+ for unlimited perdiods of time, in other words at speeds at which friction heating plays a considerable part.

• Olin Mathieson Chemical Corporation is engaged on tests with high-energy fuels based on boron. The following B.T.U. ratings are given for the various Borane derivatives investigated: Diborane 32,000 BTU/lb., Pentaborane 30,000 BTU/lb., Decaborane 26,000 BTU/lb. In contrast, the commonly used JP-4 jet fuel burns with a heat value of only 20,000 BTU/lb.

• The first *Electra* fuselage is undergoing water tank tests (pressure differential up to 9 p.s.i.). On completion of the tests, the fuselage will move into final assembly.

• The Royal Swedish Air Force is reported to be interested in the Miles M.100 *Student* light jet trainer, which it is considering for use for elementary training.

• The T2J-1 two-seat Navy jet trainer under development at North American Aviation (one Westinghouse J34 of 3,400 lbs. static thrust) wil have a top speed of 400+ knots; ceiling around 40,000 ft.; stalling speed 65 knots.—Span approx. 36 ft., length approx. 38 ft., gross weight roughly 9,000 lbs.

• The first production model of the Martin P6M *Seamaster* will be ready for flight testing in November 1957. Under present orders, a total of 28 of these four-jet combat flying boats is to be built.

World's highest rate of climb

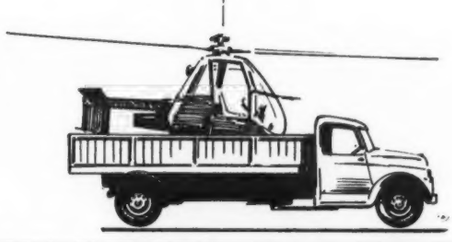
Precise Control

Negligible Maintenance
no specialist ground crew

Assembles in minutes
survives rough handling

The *FAIREY* Ultra-Light
MILITARY HELICOPTER

One three ton truck carries the helicopter, pilot, fuel and spares, *and* functions as a deck for landing and take-off, forming an entirely self-contained mobile unit.



THE FAIREY AVIATION COMPANY LIMITED - HAYES - MIDDLESEX

ENGLAND - AUSTRALIA - CANADA

Marconi's hand in Airport Radar

TYPE S232 AIRFIELD CONTROL RADAR

Operates at full efficiency in all weathers because the wavelength is long enough to be unaffected by cloud.

Removes ground clutter which obscures aircraft response by means of an extremely efficient moving target indicator (M.T.I.) system which feeds only echoes from moving targets to the display.

Is instantly operational at its rated performance because it is crystal controlled and needs no adjustment after switching on.

Conventional valves are used throughout ensuring complete reliability under the most arduous conditions of service.

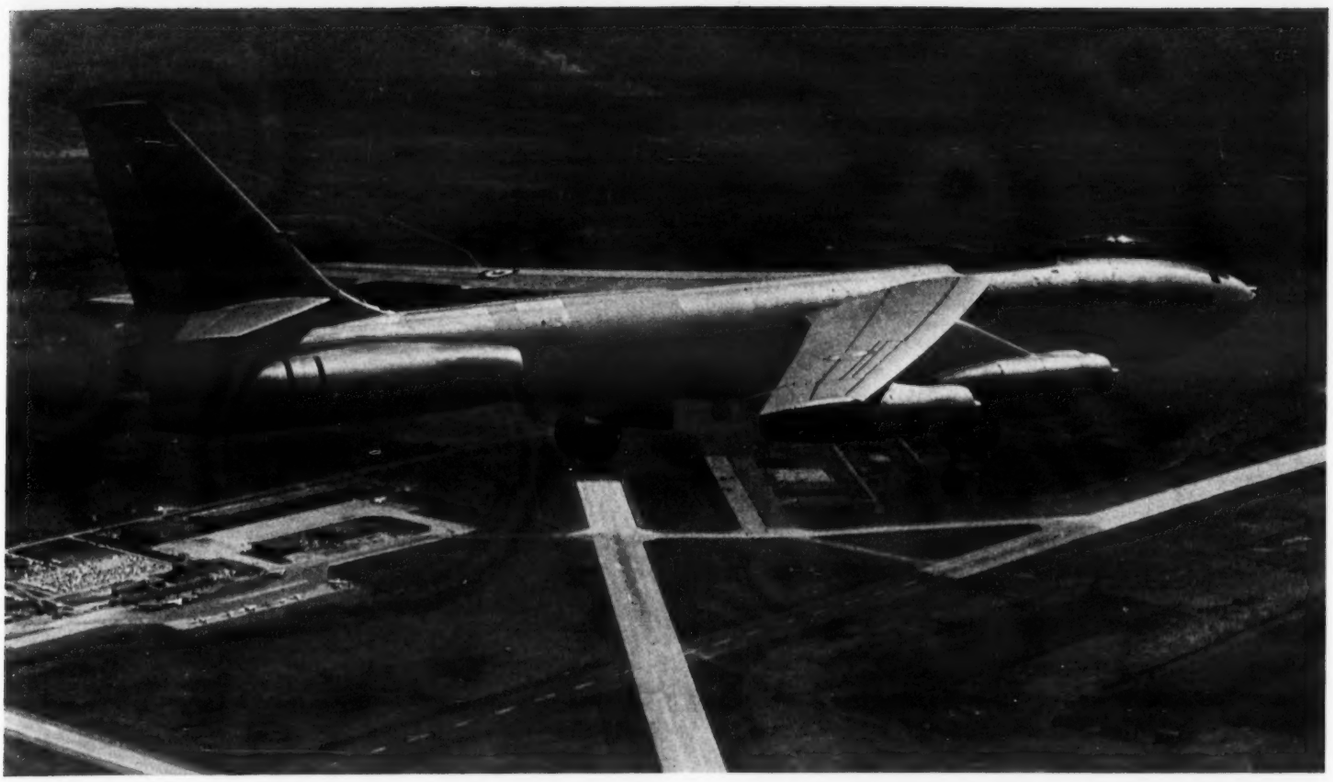
TYPE SNW 50 3 cm STORM WARNING RADAR

Storm Warning Radar can now be recognised as an important element of an Airport Surveillance and Control system.

The SNW 50 provides an accurate and up to-the-moment picture of Storm and rain producing clouds over ranges up to 200 n. miles. Remote displays, static or mobile versions are available.

MARCONI

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND



The Orenda flying test-bed in the landing circuit over Malton Airport

FLIGHT TESTING THE NEW IROQUOIS AT MALTON

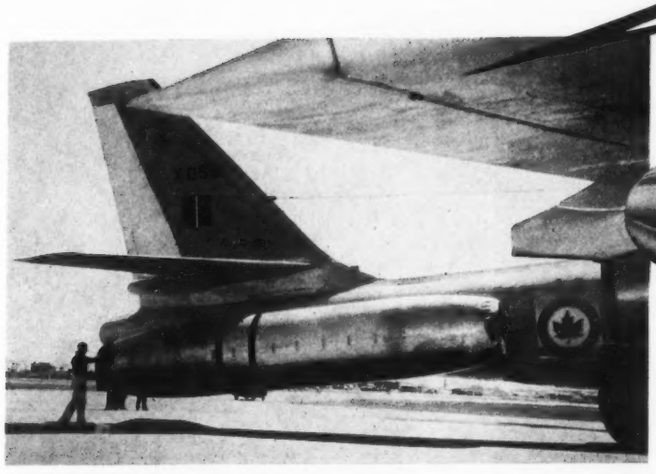
This 92-ton Boeing B-47 Stratojet is the largest and most unusual aircraft ever to operate from Toronto's Malton Airport. In this unique installation at the rear of the fuselage flies Orenda Engines' new supersonic jet engine—the IROQUOIS—which delivers power almost equal to that of the aircraft's six jets combined.

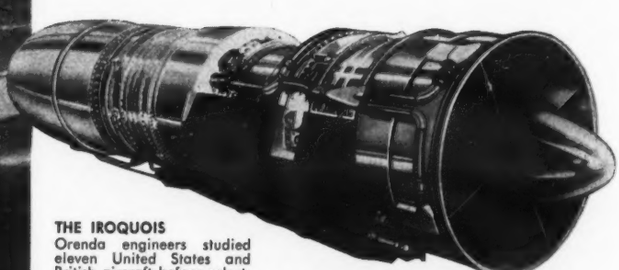
This B-47, on loan to the RCAF from the USAF, has been converted into a flying laboratory to test the IROQUOIS in the thin-cold air of the sub-stratosphere. It has an elaborate instrumentation system for recording aloft or transmitting to ground stations, data on the engine's performance.

The IROQUOIS, which will power the Avro Arrow supersonic interceptor being developed by Avro Aircraft Limited, has completed two years of ground running tests but certain problems can be answered only by actual high altitude operation.

The IROQUOIS is of very advanced design and its air testing program marks another milestone in the progress of Orenda Engines Limited which pioneered jet engine design in Canada. Thousands of Orenda Engines are in service in the AVRO CF-100 and Canadair Sabre aircraft of the RCAF in Canada and Europe. The air forces of West Germany, South Africa and the Republic of Colombia have also selected Orenda-powered Sabres.

ORENDA
ENGINES LIMITED
MALTON CANADA





THE IROQUOIS
Orenda engineers studied eleven United States and British aircraft before selecting the Boeing B-47 Stratojet. Seven possible locations were considered before the IROQUOIS was mounted in the pylon shown at left attached to the starboard rear side of the fuselage. Flying characteristics of the B-47 are almost unchanged by this unusual mounting.

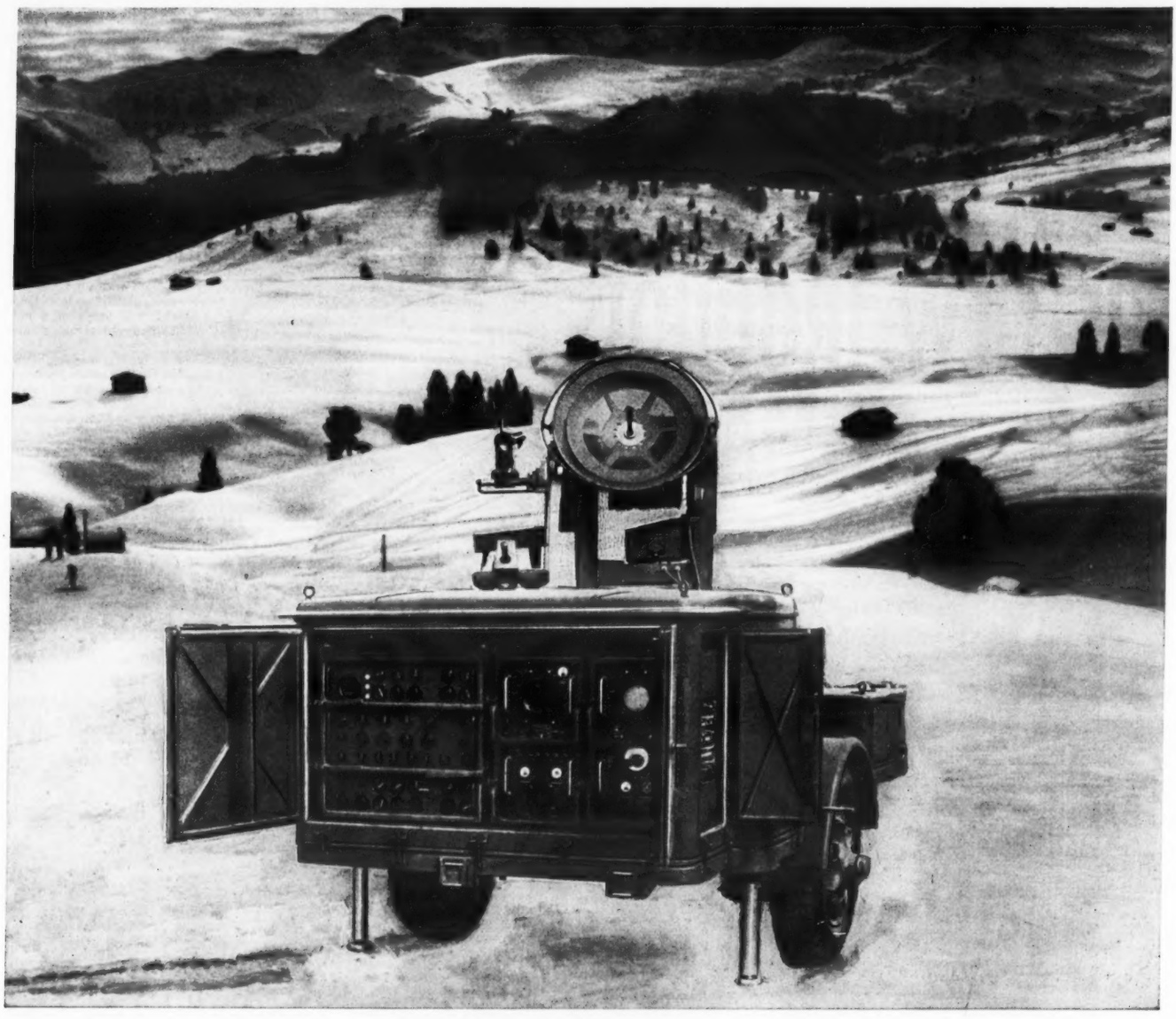
CONTRAVES ITALIANA S. p. A. ROMA

CONTRAVES has been supplying gun directors for 11 years; they are used in 11 Countries both by Army and Navy.

The Contraves directors were so designed, built and tested to operate under the most critical atmospheric conditions. Here is, for instance,

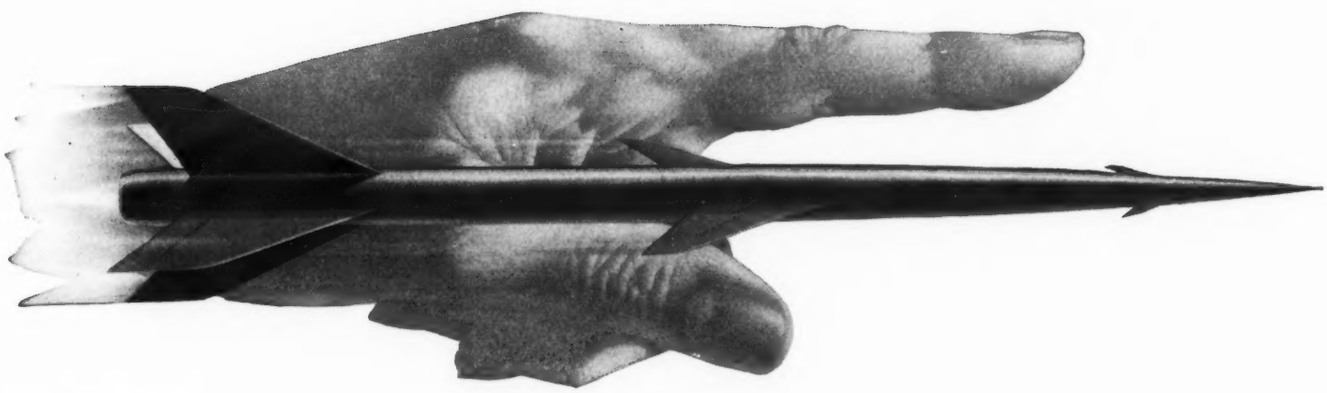
THE BAT, FIRE CONTROL SYSTEM FOR 40 mm. GUNS

while operating at very low temperature.



What next in the air? How high? How fast?

In meeting the demands for ever-increasing speed and altitude, the English Electric Aviation Group is tackling and progressively resolving the inherent problems of heating and cooling: for, apart from aerodynamic shape, future performance will be governed more and more by the ability of materials and components to endure a rapidly widening range of temperatures.
Whatever is to be the future of aviation, it is now being foreshadowed on the drawing-boards of English Electric, Marconi's and Napier—three famous firms sharing talents, experience and resources in the English Electric Aviation Group.



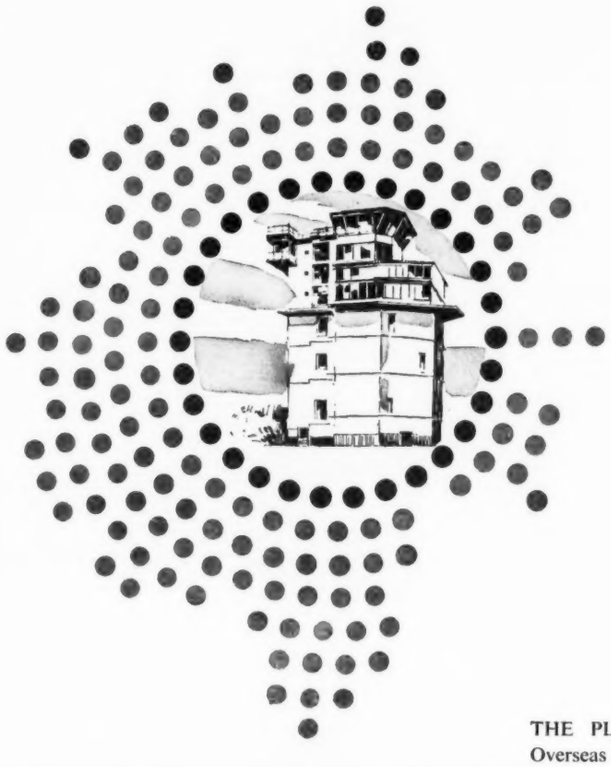
The projects on which we are now working are secret but our achievements speak for themselves—
English Electric produce the famous Canberra and supersonic P.1., and are now foremost in the development of Guided Weapons; Marconi's are pre-eminent in radar, radio and navigational aids; and Napier are renowned for experience in the design and production of gas turbines, ram jets and rocket motors.

English Electric · Marconi · Napier

THE BIG THREE WHO MAKE UP THE 'ENGLISH ELECTRIC' AVIATION GROUP

for Aeronautical Radio Teleprinter circuits

H.F. Transmitting and receiving equipment by **Plessey**

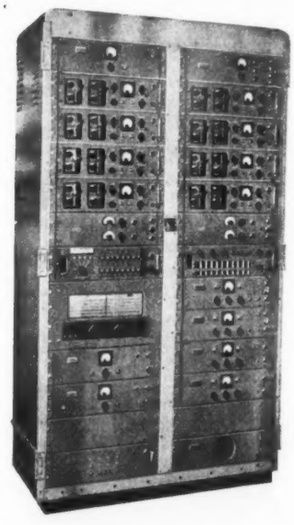


Under I.C.A.O. recommendation more circuits are changing over from hand morse to R.T.T. Many will again look to Plessey for the most efficient equipment. In conjunction with International Aeradio Limited, Plessey has designed and produced a range of H.F. equipment which offers many facilities not found in other R.T.T. equipment. Plessey equipment represents the most economical and convenient way of converting to the new method of working. Economical—because of the minimum initial cost. Convenient because unit construction enables individual operational requirements to be met and, later, the "Add-on" facility allows installations to be expanded as activity increases.

manufactured by Plessey in collaboration with International Aeradio Limited

THE PLESSEY COMPANY LIMITED, ILFORD, ESSEX, ENGLAND
Overseas Sales Organisation :— Plessey International Limited

PVR 80 Receiving Terminal. Four channels. Local or Remote Control.

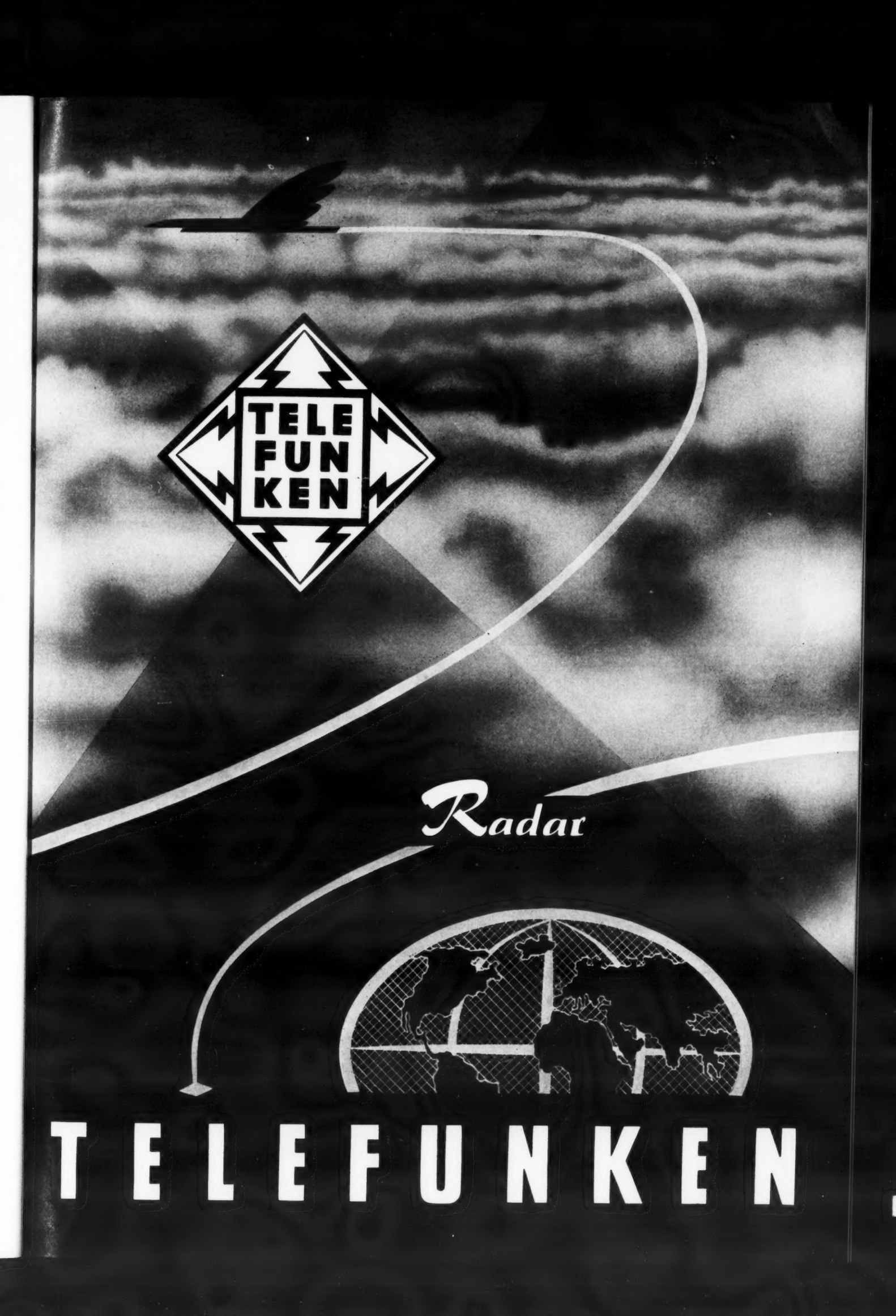


Frequency range : 2—30 Mc/s
Shift frequency: 200—850 c.p.s.

PVR 102A Receiving Terminal. Five channels. Local or Remote Control.

PVT 90 Transmitter Drive. Four channels. Local or Remote Control.

EES


TELE
FUN
KEN
Radar
TELEFUNKEN

The end of a perfect flight

We may safely leave it to the Aircraft Industry to design the planes for the perfect flight. They will get nearer to this target every time. But the perfect flight entails more than fast, reliable and comfortable aircraft. It also calls for the most advanced traffic control methods. And that is where Philips multi-channel automatic recorders come in. The 15-channel system depicted here contributes to the perfection of numerous flights ending (or starting) in France, Switzerland, the Near East, North Africa and Latin America.

PHILIPS

PHILIPS

Multi-Channel Automatic Recorders

U.S. Airlines and Aircraft Industry at the End of April, 1957

by Scott Hershey, New York

Certain details in the following stock market analysis may be out of date by the time the June issue of Interavia *appears. For example, the C.A.B. may have made its decision in the matter of the domestic fares increase requested by the airlines. Nevertheless, no editorial changes have been made, as the article provides an instructive overall picture of the situation. — Editors.*

Aircrafts

Aircraft stocks generally continued to be whip-sawed by changes in Defense Department policies on jet bombers and expectations of more emphasis on guided missiles. William M. Allen, Boeing president said, however, that the production stretch-out for the B-52 bombers recently announced by the Air Force has not altered the company's earlier forecast for substantially increased sales in 1957. Boeing and North American were the most active aircraft performers as the market closed out the month. One day 29,600 shares of Boeing were traded with the stock closing at 47 3/4. North American shares traded the same day amounted to 27,100 and closed at 30 5/8.

Selective trades have kept the list lively, and the market as a whole was around the best of the year, which was mid-January. The last week in April showed the market at the fastest pace of the year, with volume edging toward the 3,000,000 share-a-day level on several occasions. Aircraft stocks for the most part closed out the month only slightly above their lows for the year.

Some examples of highs and lows for the year showed: Boeing: high 61 1/8, low 45; North American: high 39 1/4, low 27 1/2; United: high 90 1/4, low 72 1/4; Douglas: high 91, low 75 1/8; Lockheed: high 57 1/8, low 44 1/4; Republic: high 33 3/4, low 23 7/8; Fairchild: high 12 1/4, low 10 1/8.

Airlines

The market action of airline stocks in coming weeks is expected to be influenced largely by developments in the general passenger fare investigation now being conducted by the Civil Aeronautics Board.

Earnings evidence for 1957 to date for the carriers tends to support a theory of a profits squeeze, although the outlook is subject to various views. Many industry leaders are leaning toward the pessimistic side if a fare increase is not granted. As public hearings are held in coming weeks, it is likely that much publicity will be given these pessimistic feelings. This obviously could work against any substantial recovery of the airline group.

In almost every airline annual report for 1956 issued to date, a profits squeeze is forecast with airline traffic mounting, but earnings going the other way. The biggest argument of the airlines in their plans for a 6 % fare increase, and in their presentations in the general fare investigation is the contrast between rising costs and static airline fares.

The general investigation originally was started to see whether a general *reduction* in passenger fares was not necessary due to the favorable earnings of 1955. Unfortunately, industry earnings declined below the 1955 level in 1956 due primarily to a cost squeeze, bad flying weather and several other "non-recurring" factors.

It is impossible at this time to tell whether a fare increase will be granted, how much it might be and when it could take effect if granted. A reasonable fare increase in the near future would leave room for some market optimism.

Some observers believe that shares of some of the smaller carriers may be buoyant from time to time regardless of the course of the investigation hearings. This could be in line with developments in several important route cases now in process. Continental Air Lines, for example, may outperform the airline group. It went into big-time operation at the end of April with service on the new Chicago-Los Angeles route with DC-7B equipment. Also, Continental will be the first company to offer turboprop service in Western United States some time next year.

The Great Lakes-Southeast route case could benefit Delta and National. And on the West Coast, Western Airlines will start operations soon on the Los Angeles-Mexico City run, which should add to earning power. Possibilities of favorable decisions in other route cases could add to growth potential of lines affected.

It should be noted that some investment men and bankers are not taking the pessimistic views reflected in some of the annual airline reports too seriously. They suggest that perhaps some of the airlines, to meet any possibility of a fare reduction posed by the C.A.B. and to support their position of static fares and rising costs, may be painting the picture blacker than it really is. One carrier reportedly has just arranged a new large bank credit although it currently is operating in the red. One Wall Streeter remarked that the cost figures shown the banks must be more cheerful than the ones being presented to the C.A.B.

Briefs

Latest airline arrival on the Big Board is *Delta Airlines, Inc.* First trading in the common stock began April 17th with a 500 share block at 26 1/4. Delta common has been traded over-the-counter with the last quote in that market at 24 7/8 bid and 26 7/8 asked ... *Chance Vought* is considering a convertible debentures issue and other sources of revenue to obtain additional capital this year. The company has a backlog of orders in excess of $500,000,000. To meet this and other requirements the company figures it needs $12,000,000 above its bank credit line ... *Lockheed* observed its 25th anniversary of operations with orders totalling $1,597,523,000 at year's end, an increase of 31 % over the previous year ... Company sales and unfilled orders of *The Martin Co.* are at the highest levels except for two war years, 1943 and 1944. Of the $810,000,000 backlog, more than half is for guided missiles ... *Pan American* reported for 1956 net income after taxes of $14,200,000 equal to $2.31 a share, compared with $10,200,000 or $1.66 a share in 1955. Total operating revenues reached a record $289,000,000, an increase of 21.4 % over the previous year ... *Seaboard and Western* achieved its best first quarter in five years, reporting that military traffic which provided 65 % of the company's revenues in 1956 accounted for only 10 % this quarter.

INTERNATIONAL MEETINGS AND CONFERENCES

June 1st-9th : Annual National Aviation Trade Show. Monmouth County Airport, N. J.

June 1st-20th : 25th International Samples Fair. Barcelona.

June 3rd : IATA - Executive Committee. New York.

June 9-10th : FAI - Vienna-Aspern International Rally (Austrian Aero Club). Vienna-Aspern.

June 9-14th : ASME - Semi-Annual Meeting, American Society of Mechanical Engineers. San Francisco.

June 9th-23rd : 26th International Fair. Poznan.

June 10th : 6th International Air Show (Royal Netherlands Aero Club). Ypenburg.

June 10-13th : ARS - Semi-Annual Meeting, American Rocket Society. San Francisco.

June 14-16th : SAFE - Study the Atom for Future Efficiency, Congress, Bingley Hall. Birmingham.

June 17th : ICAO - Jet Operations Requirements Panel 3rd Meeting. Montreal.

June 17-19th : IRE - Professional Group, National Convention of Military Electronics. Washington.

June 17-20th : IAS - Institute of the Aeronautical Sciences, Summer Meeting. Los Angeles.

June 18th-July 9th : WMO - Commission for Aerology (CAe), 2nd Session. Paris.

June 18th-July 9th : WMO - Commission for Instruments and Methods of Observation (CIMO), 2nd Session. Paris.

June 21st-24th : FAI - 9th International Round-Sicily Flight (Palermo Aero Club). Palermo.

June 25-30th : FAI - Fédération Aéronautique Internationale, Annual Meeting. Palermo.

June 30th-July 3rd : IPE - Automatic Production - Change and Control Conference (Institution of Production Engineers). Harrogate, England.

July 5-8th : FAI - Switzerland : 3rd International Watch Rally (Swiss Aero Club). Bienne.

July 9-14th : FAI - Italy : International Aviation Week (Pescara Aero Club).

July 10-20th : International Plastic Exhibition & Convention. London.

July 11-13th : Royal Aero Club National Air Races.

July 12-13th : FAI - British Lockheed Trophy, International Aerobatics Contest. Baginton, Coventry.

July 22nd-August 3rd : Industrial Fair. Sydney.

July 27th-August 4th : 39th Swedish Samples Fair. Malmö.

July ...th : IATA - Preparatory Meeting to ICAO SAM/SAT Regional Air Navigation Meeting. Rio de Janeiro.

Aug. 5-10th : IAS - National Naval Aviation Meeting. San Diego.

The Mind of Mr. Reader

Electro-Gravitics

Sir,

...May I take this opportunity also to tell you what a splendid job Interavia has done in aviation reporting and especially in the field of electro-gravitics. But don't stop now in this new and interesting field—it has only begun !

St. Paul, Minnesota.

Ronald MONROE.

Those flying saucers again !

Sir,

In answer to the request on Electro-Gravity, you really covered the space front in December, although only a few outlines were left out. The design and type of Flying Saucers were left out. The article by Mr. Lucien A. A. Gerardin was very good but if the layout could be illustrated by drawings showing some ways this is put to use in the ship. The next one could show how this could be applied here and eventually to outer space. Many ideas and theories explained but not many laid out for simple picture illustration.

From all the stories of Flying Saucers, the power source must be of atomic, or some solar type power...

This device must be undoubtedly developed or near the last stage because, if our neighbor planets are populated, advancement here is and should be accelerated in a high gear shape now.

Could you or would you gather some of the facts known to the Geophysical Dept., as of 5 years ago, on all inhabited planets, people and environment. I heard of a source where if the people of the world could actually see and understand what the men of Palomar and Wilson and others have on hand for evidence, they would think Buck Rogers was no flameout sure enough.

See if you can or will obtain information on this and run a full house coverage telling exactly how many of the 200,000,000 stars are inhabited, advancement of races, history, atmosphere and releasable pictures of telescopic information that will show the people here we are not all by ourselves as we think. If this is the case, there must be more to the urge of space travel than just the 1957 space station.

If you will or could crack this information and show color plates and the shortest timetable and the hope of return as now planned in the next 5 years, well I think you would have really covered and discovered one half the saucer mystery around the world today as no other magazine has.

Ask your staff and writers to go over these facts and information from Palomar and Wilson or Flagstaff, Arizona. I am sure the staff and men who read the odd informaton pieced together could and should discover this mystery soon.

Sharpes, Florida.

George HUGHES, Jr.

Interavia must regretfully decline Reader Hughes' suggestion. It just does not feel up to beginning the Geophysical Year with a flying start into the field of flying saucers, a subject which it still regards as somewhat " fragile ".

Editors.

More aviation history, please !

Sir,

...I particularly enjoy your excellent, though regretfully infrequent, historical articles...

Godfrey, Illinois.

James E. BLOUIN.

Reader Blouin's interest finds full support among Interavia's Editors, who will do their best to provide more space in future for aviation history.

Were we unfair to the Grumman WF-2 ?

Sir,

In reference to the photo-caption on page 335 of Interavia—April, why did you get off the track by trading a Tracker for a Trader ?

Rotterdam, Holland.

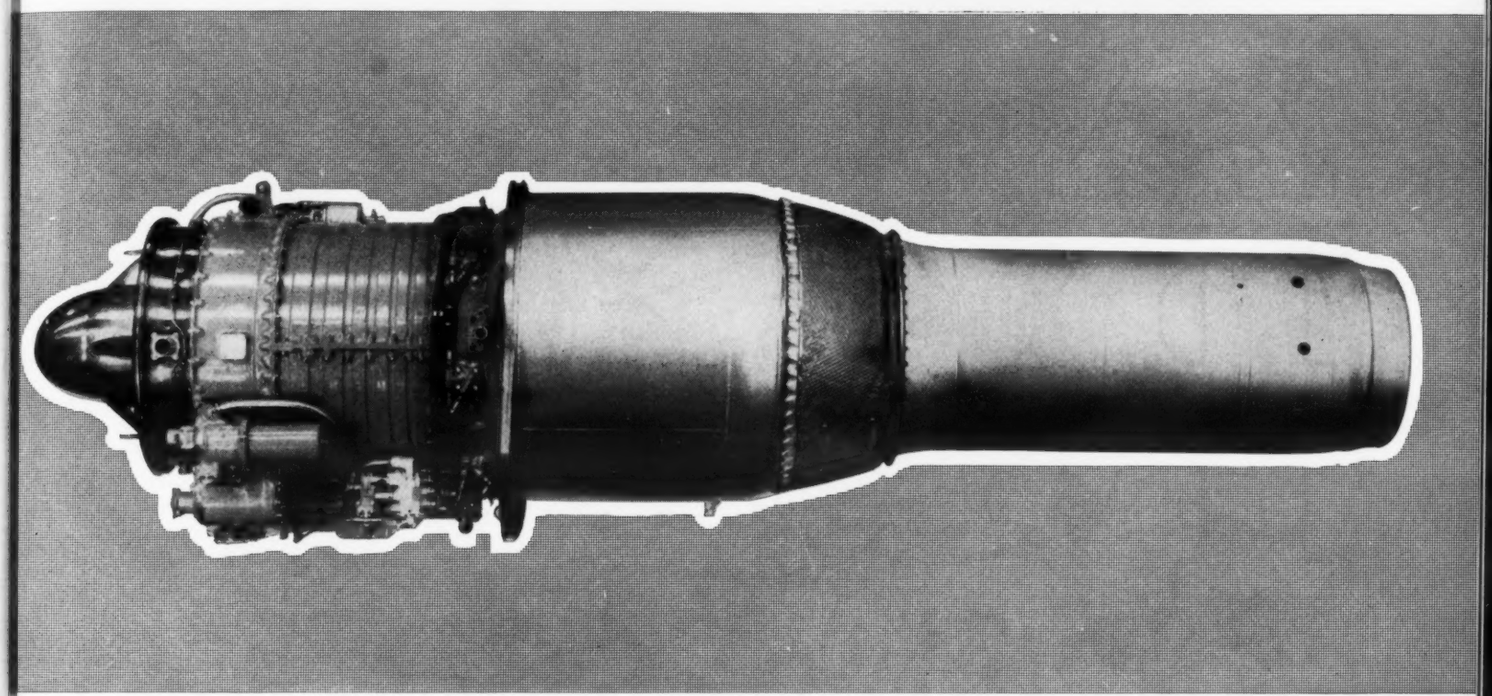
G. WIEDERHOLD.

Sorry, Reader Wiederhold, but Grumman describes the WF-2 as " a development of the passenger-cargo TF-1 'Trader' ". The " Tracker ", again according to Grumman, is the S2F-1 and S2F-2, another member of the same basic aircraft series.

Editors.

Photo credits : Front cover : Federal Telecommunication Laboratory ; pp. 549-552 : Kantonale Bau-Direktion, Zurich (2), manufacturers (5) ; pp. 553-556 : manufacturers (10), Interavia drawing (1) ; pp. 561-562 : manufacturers (4), Interavia drawing (1) ; p. 563 : manufacturers ; pp. 564-565 : manufacturers (8), Interavia (1) ; pp. 566-568 : U.S. Navy (2), U.S.A.F. (7) ; pp. 573-574 : manufacturers ; pp. 575-577 : manufacturers ; pp. 578-581 : author (4), U.S.A.F. (5), U.S. Navy (3), R.C.A.F. (1) ; pp. 582-583 : Interavia files ; pp. 584-585 : Interavia files ; pp. 586-588 : R.A.F. (1), U.S.A.F. (1), U.S. Navy (1), manufacturers (17), Interavia files (3) ; p. 593 : Interavia drawing ; pp. 594-596 : manufacturers ; pp. 598-599 : manufacturers.

BRISTOL ORPHEUS FOR NATO LIGHTWEIGHT FIGHTERS



ORPHEUS B Or 3. The most advanced turbojet engine in its class. 6,500 hours bench and flight running have been completed. The Orpheus B Or 3 has a static thrust of 4,850 lb. The recently announced B Or 11 is rated at 5,760 lb, and still more powerful versions are being developed.

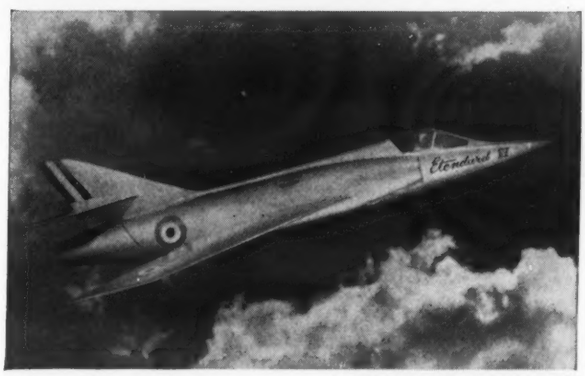
Dimensions: OVERALL LENGTH 96·1 in (without jet pipe). DIAMETER 32·4 in.

The Orpheus is the only engine specifically developed for *lightweight* fighters. Three Orpheus-powered aircraft—the Fiat G 91, the Dassault Etendard VI and the Breguet 1001 Taon—have been ordered for evaluation by NATO. The Orpheus also powers the Folland Gnat, the Fuji TIF-1 trainer and the Hispano HA 300 interceptor, and has been specified for a number of very advanced aircraft now being developed in several countries.

The Bristol Orpheus is a simple-to-build, simple-to-service turbojet that has a better power-to-weight ratio than any other long-life engine. Its lightness makes it the ideal power unit for the new generation of small economical fighters now emerging from the aircraft factories of Europe.

BRISTOL
Aero-Engines

The Fiat G 91



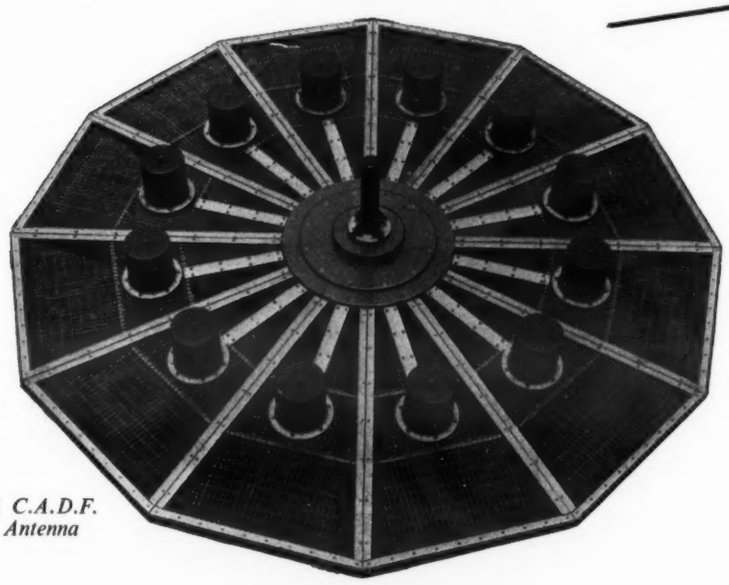
The Dassault Etendard VI

C.A.D.F.

COMMUTATED ANTENNA DIRECTION FINDING

An entirely revolutionary method of RADIO DIRECTION FINDING. The most notable advance in Direction Finding since the introduction of the Adcock aerial in 1916.

Another advance by *Standard*



A C.A.D.F. Antenna

Applicable to the H.F., V.H.F. and U.H.F. bands.

- **Major reduction of site errors, up to ten times better than a conventional Adcock system.**
- **Interference eliminated by "capture effect".**

Engineered for land or ship-borne use.

Standard Telephones and Cables Limited

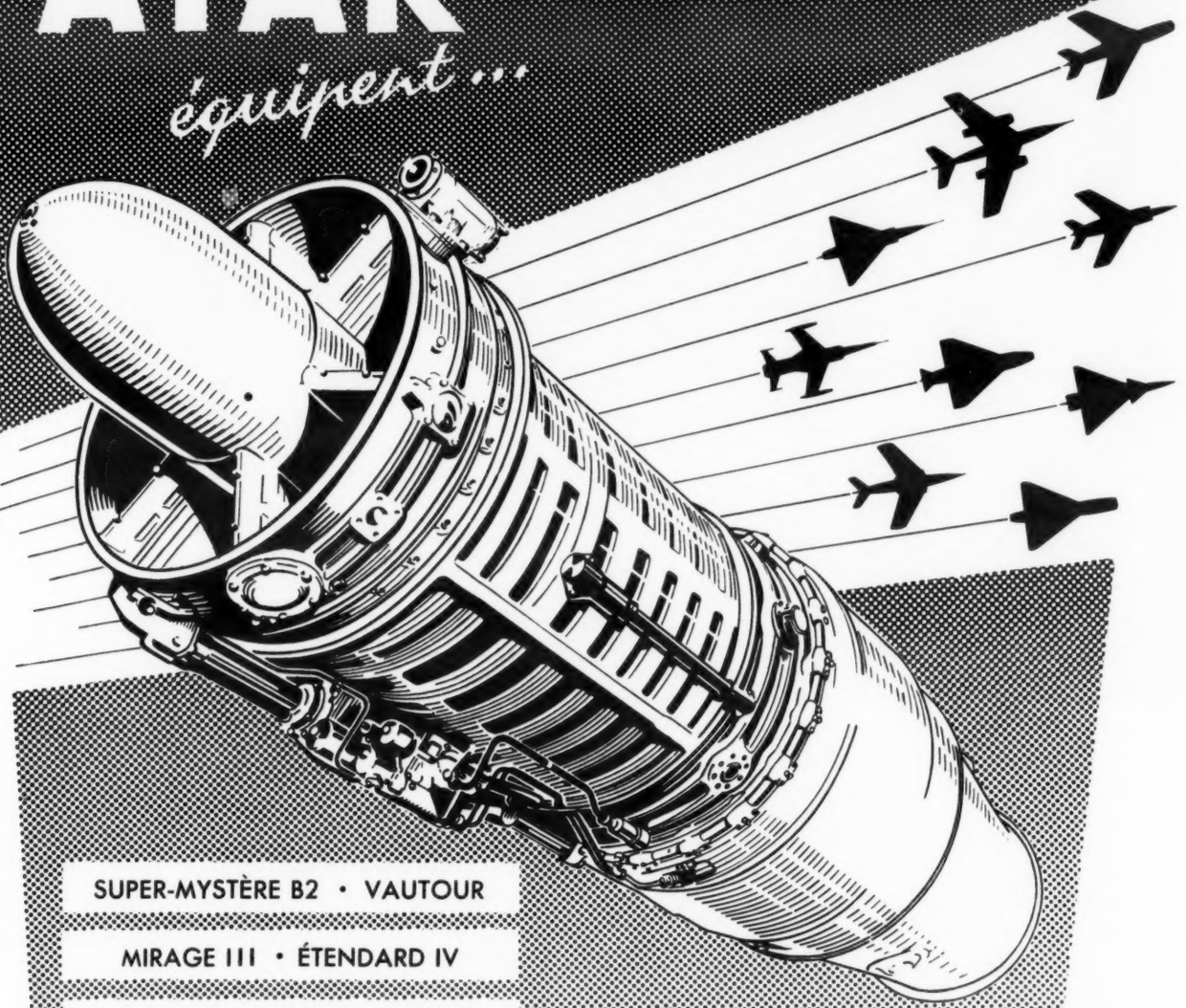
Registered Office: Connaught House, Aldwych, London, W.C.2

RADIO DIVISION: OAKLEIGH ROAD · NEW SOUTHGATE · LONDON N.11

LES TURBO-RÉACTEURS

ATAR

équipent...



SUPER-MYSTÈRE B2 • VAUTOUR

MIRAGE III • ÉTENDARD IV

LEDUC 0-22 • GERFAUT • GRIFFON

BAROUDEUR • DURANDAL

SOCIÉTÉ NATIONALE

D'ÉTUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION

150, BOULEVARD HAUSSMANN PARIS-VIII[e]

Air France flies in the forefront of progress

Photo J. BUTLE

OVERHAULED FOR EACH DEPARTURE

Each time an Air France plane takes off on a new journey, every part, strut, pedal, bolt and wire is checked, tested, overhauled and checked again - by more than 6,000 mechanics and engineers in Air France's Orly Workshops.

The maintenance check of a Super-Constellation, for instance, requires a minimum of 43,800 technical man-hours of work : an example of how Air France handles upkeep on one of the world's biggest and most up-to-date airlines.

IMPRESSIVE SCORE : 99.6 % PUNCTUALITY

One reason why the Air France score for punctuality is 99.6 % is top-notch technical services. Another is flight crews – each crew member totals tens of thousands of flight hours over millions of miles of air-routes.

●

SAFETY AND PUNCTUALITY

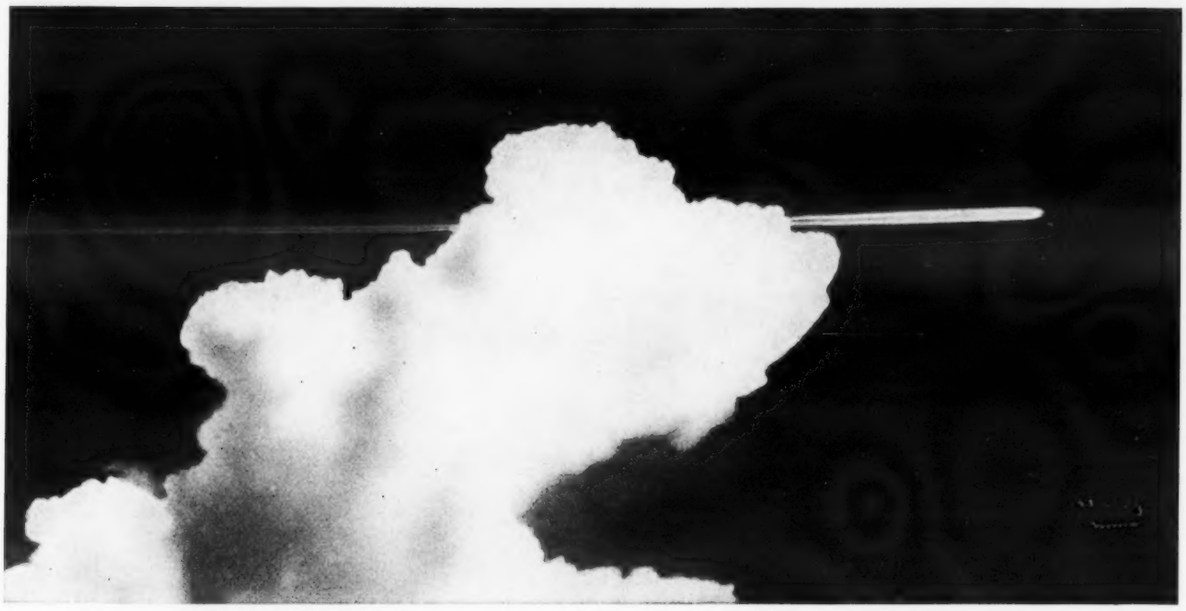
TWO GREAT AIR FRANCE ASSETS DUE TO 38 YEARS OF EXPERIENCE IN THE SERVICE OF PROGRESS

AIR FRANCE

THE WORLD'S LARGEST AIR NETWORK

IN THE FOREFRONT OF PROGRESS

The world's most experienced builder



# of long-range jet aircraft brings you

The Boeing 707 jet prototype, photographed in flight over the Cascade Mountains (November, 1954)

the jet airliner of tomorrow...

There is only one American jet airliner now in the air — the Boeing 707. *It has been flying more than two years.*

In the superb 707 you will cruise smoothly six miles high, 600 miles an hour. Eleven famous airlines* have chosen Boeing jets... for many reasons, including this: when deliveries begin in less than two years, the 707 will be the most tested airliner ever to take to the skies.

Boeing leads in jetliners - because Boeing, back in 1952, had faith in the future of jet transportation, and began actual construction of America's first jet transport.

BOEING 707

*AIR FRANCE · AIR INDIA · AMERICAN · B.O.A.C. · BRANIFF · CONTINENTAL · LUFTHANSA · PAN AMERICAN · QANTAS · SABENA · TWA

VERTOL tests world's first Tilt-Wing VTOL Research Aircraft

The new Vertol 76 is a true Vertical Take-Off and Landing (VTOL) aircraft, an experimental vehicle that casts a large shadow into the future.

With its ability to take off, hover and land like a helicopter it is independent of all but the most rudimentary landing area. Yet it flies from point to point with the dispatch of a turbo-prop passenger plane.

In this pioneer air vehicle the wing and roto-propellers tilt as a unit through a 90° arc at the will of the pilot. For vertical flight he rotates the wing upward. To fly level he tilts the wing forward. Given a small runway, he can set the wing at the most effective angle to operate Model 76 as a Short Take-Off and Landing (STOL) aircraft and thus increase payload potential.

Engineers, if you are not already working for the government or defense industry, investigate job opportunities with Vertol.

The Model 76, soon to undergo flight tests, has been developed by Vertol for the Army Transportation Corps and the Office of Naval Research as part of the military's ceaseless quest for greater mobility and efficiency. From flight tests will come experience and knowledge applicable to the bright future of VTOL in military and commercial aviation.

Since 1943 Vertol has been a pioneer in research and development of vertical lift aircraft. It is now the largest independent manufacturer of helicopters. You may find that our know-how, our experienced personnel, our test facilities and our productive capacity can help you solve a problem.

VERTOL Aircraft Corporation

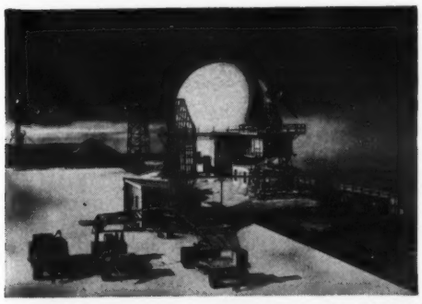
MORTON, PENNSYLVANIA

What Do You Look For In Radar?

For Equipment To Meet Your Needs Today And Years Ahead!

AND GENERAL ELECTRIC HAS IT...

Air traffic control radar and airport surveillance radar MUST be designed with today's requirements and tomorrow's demands in mind. Critically overcrowded airways, plus the coming of the jet transport era, make it imperative that any radar installation be equipped with the finest — and that is General Electric Radar, produced through world-famous research and development programs. These programs benefit you, when you order G. E.



Shangri-La, G. E.'s radar test center, where this advanced equipment was developed and perfected.

AIRPORT SURVEILLANCE RADAR

Permits the Air Traffic Controller to expedite traffic flow by providing absolutely accurate information to permit three-mile minimum separation between aircraft.

General Electric ASR equipment provides: • Better control of high density traffic through sharp, accurate visual presentation • Improved MTI circuits to eliminate unwanted clutter • Dual Channel system to permit continuous operation even during maintenance • Remote console operation up to two miles • Greatly increased airport landing and departure capacity.

LONG-RANGE RADAR

Designed for Air Traffic Control to supply accurate information on aircraft location in "en route" rather than terminal areas.

General Electric Long Range Radar provides: • Reduced aircraft separation, expediting traffic now highly restricted by the time separation in non-radar operation. • Better control through complete area coverage in a single installation • Establishing location of lost aircraft • Assisting aircraft to detour around adverse weather • Prevention of mid-air collisions through complete airspace monitoring. EP-56-9

Other General Electric Radar Equipment:

SEARCH RADAR • HEIGHT FINDER RADAR • AIRBORNE RADAR SYSTEMS, INCLUDING NAVIGATION

For further details, write Electronics, Dept. I

International General Electric Co., 150 East 42nd Street, New York 17, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

—U.S.A.—

Announcing....
THE TACAN
DATA LINK
A New Aid for Improved Air Traffic Control
THE TACAN SYSTEM, DEVELOPED BY
IT&T LABORATORIES IS PRODUCED IN FRANCE BY
L.M.T.
46, QUAI DE BOULOGNE - BOULOGNE-BILLANCOURT (SEINE) - TEL: MOL. 50-00

Less than 48 hours after this pilotless plane landed itself in the desert, Douglas Field Service men were on hand

Due to landing gear trouble, the entire crew of this A3D abandoned the aircraft in mid-air, parachuting safely to the ground. Showing marked stability, the airplane went on to land itself in salvageable condition 45 miles from the nearest town.

Douglas Field Service and factory men joined a combined Navy, Marine and Air Force team that disassembled the airplane and removed all trace of the crash-landing within five days.

This immediate backing for the operators of Douglas equipment anywhere in the world is typical of the Douglas Field Service operation. Wherever Douglas airplanes or missiles may be, whether their mission is military or commercial, Douglas Field Service men are ready to do everything possible to see that they achieve maximum utilization.

Depend on
DOUGLAS
Service

Reliable, fast, highly economical and easily manoeuvrable

is the renowned Czechoslovak aircraft, the

AERO SUPER

It can be used for sports flying, as an aero-taxi or for feeder liner duties. It is also suitable for flight training.

Brief technical specifications

The AERO SUPER is a cantilever twin-engined low-wing monoplane with an enclosed cabin accommodating the pilot and three passengers. It is powered by two Walter Minor 4-III engines of 105 b.h.p. each, with type V 401 electrically controllable pitch propellers. Its range is 1500 km, its fuel consumption rate being 50 litres per hour.

Apply for a detailed offer from the **Omnipol Ltd.** Praha 3, Washingtonova 11

Representatives: **Argentine:** Dr. M. L. Insura, Arenales 1161, Buenos Aires — **Austria:** Ing. A. Rutte, Berggasse 16, Wien IX — **Belgium:** R. Heuvelmans, 36 Avenue Albert-Jonnart, Bruxelles — **Denmark:** Hammers-Luftfahrt, Vesterbrogade 54, Kobenhavn V — **Finland:** Mateko O. Y., Mariankatu 15, Helsinki — **France:** Henri de Montmarin, 22, rue Georges-Bizet, Paris 16 — **German Federal Republic:** Autohage m.b.H., Schmittstrasse 47, Frankfurt a. Main — **Holland:** R. Uges, Handelmaatschappij " Het Oosten ", 27, Thierenskade, Rijswijk ZH — **Switzerland:** Aero-Craft, Bahnhofstrasse 77, Zurich.

Extra miles of extra smoothness with ELAND

There are two basic Eland facts which every airliner operator should know: its high-return efficiency and its low-cost maintenance. Passengers may neither know nor care about such things, but they too will notice the Eland. They will like the exceptionally low level of cabin noise, they will like the absence of beat, whine and whistle. More important still, they will remember those aircraft that do *not* have the advantages of smooth turbo-prop flight—and avoid them.

THE MOST PRACTICAL PROPOSITION

In this space it is only possible to mention a few of the reasons why the Eland is the most *practical* engine airlines can invest in . . . but here they are.

1. Faster and further—larger payloads—longer distances.
2. Easier maintenance—unit construction gives maximum component life.
3. Greater safety—fundamental simplicity in design together with new built-in safety devices give maximum reliability.
4. Longer future—this decision must be taken eventually by all progressive airlines. Of turbo-prop investments the Eland offers the surest dividends.

PISTON v. TURBO-PROP

As piston engines wear out airline operators may decide to replace with new Eland-powered craft. From a financial point of view, however, it may be that *conversion* is the better proposition; it has been estimated that a Convair 340 conversion operating over stage lengths of 200 miles with a utilisation of 3,000 hours per year and a load factor of only 65% would show a profit increase of $100,800 per year over the piston engine version. On routes with stage lengths of 800 miles a fleet of 20 Eland Convairs in similar conditions would show more than $3,000,000 extra profit annually. These are figures no airline operator can ignore.

the era of the ELAND is beginning

NAPIER D. NAPIER AND SON LIMITED · LONDON · W.3 · ENGLAND

Partners in Progress with The ENGLISH ELECTRIC Company Ltd.

AFTER THREE YEARS OF SYSTEMATIC TESTS ON SUCCESSIVELY IMPROVED PROTOTYPES

THE T.P.C. RADAR SYSTEM

T.P.C.

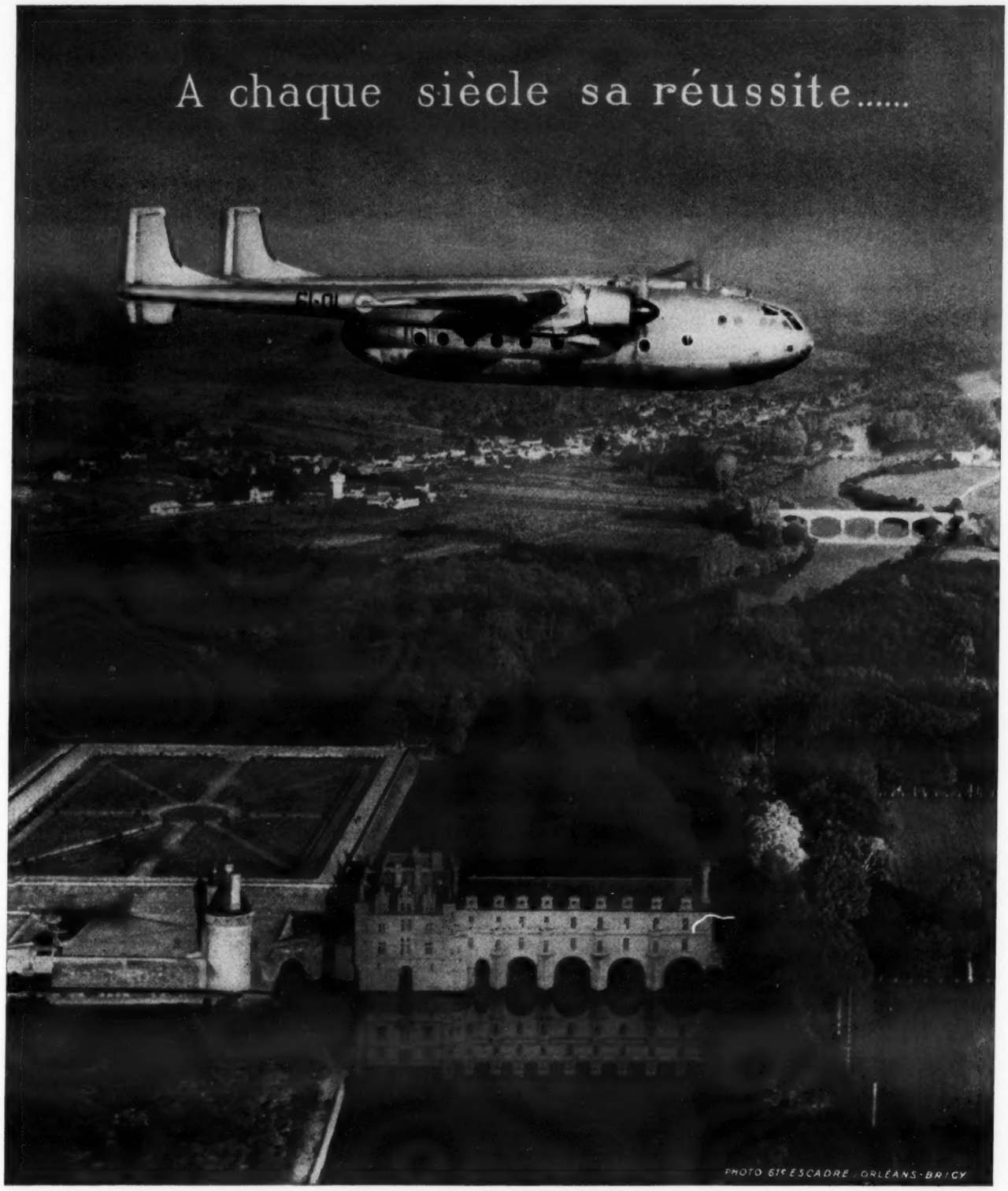
FOR THE FIRE CONTROL OF MEDIUM-CALIBRE ANTI-AIRCRAFT BATTERIES IS NOW IN

QUANTITY PRODUCTION

UNEQUALLED TECHNIQUE •
PROVEN PRECISION •
RUGGED DESIGN •

THOMSON CFTH HOUSTON

COMPAGNIE FRANÇAISE THOMSON-HOUSTON - GROUPE ÉLECTRONIQUE - 173 Bld. HAUSSMANN - PARIS 8e

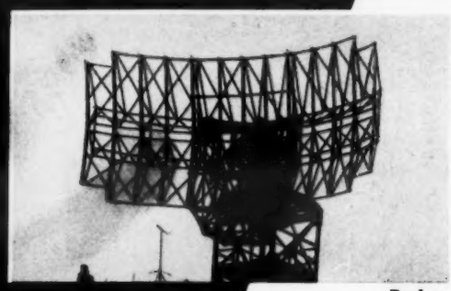


S.N.C.A.N

Société Nationale de Constructions Aéronautiques du Nord

2 à 18, RUE BÉRANGER - CHATILLON-S/S-BAGNEUX

(SEINE) TÉL. ALÉSIA 57-40



Radar

Radio navigation

Electronic computers

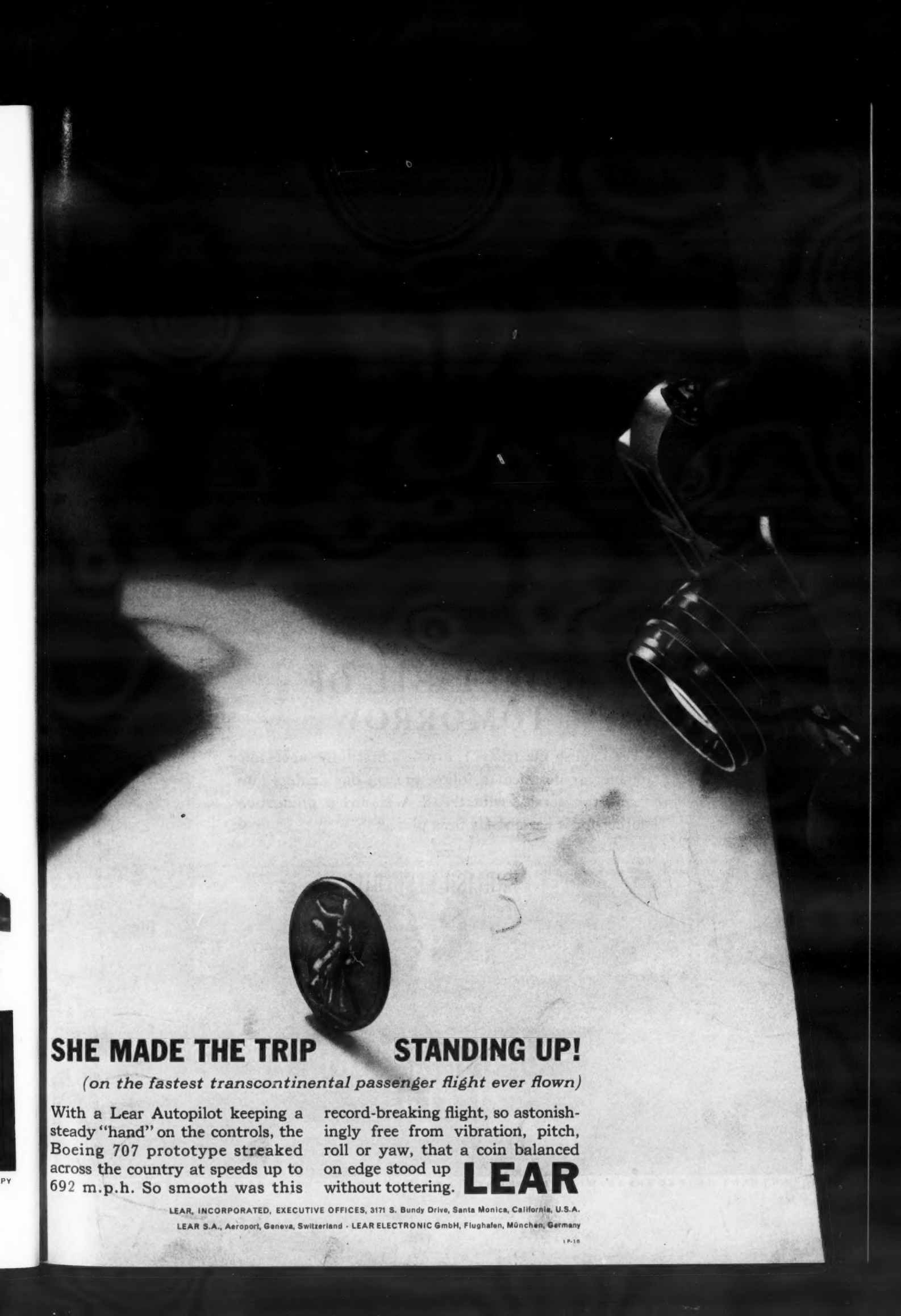
CSF airborne radar

is fitted in the production

VAUTOUR. SNCASO fighter

COMPAGNIE GÉNÉRALE DE TÉLÉGRAPHIE SANS FIL
Direction Commerciale et Division Internationale
79, Boulevard Haussmann - Paris VIII - ANJou : 84-60
SOCIÉTÉ FRANÇAISE RADIO-ÉLECTRIQUE

PUBL. RAPY



SHE MADE THE TRIP STANDING UP!

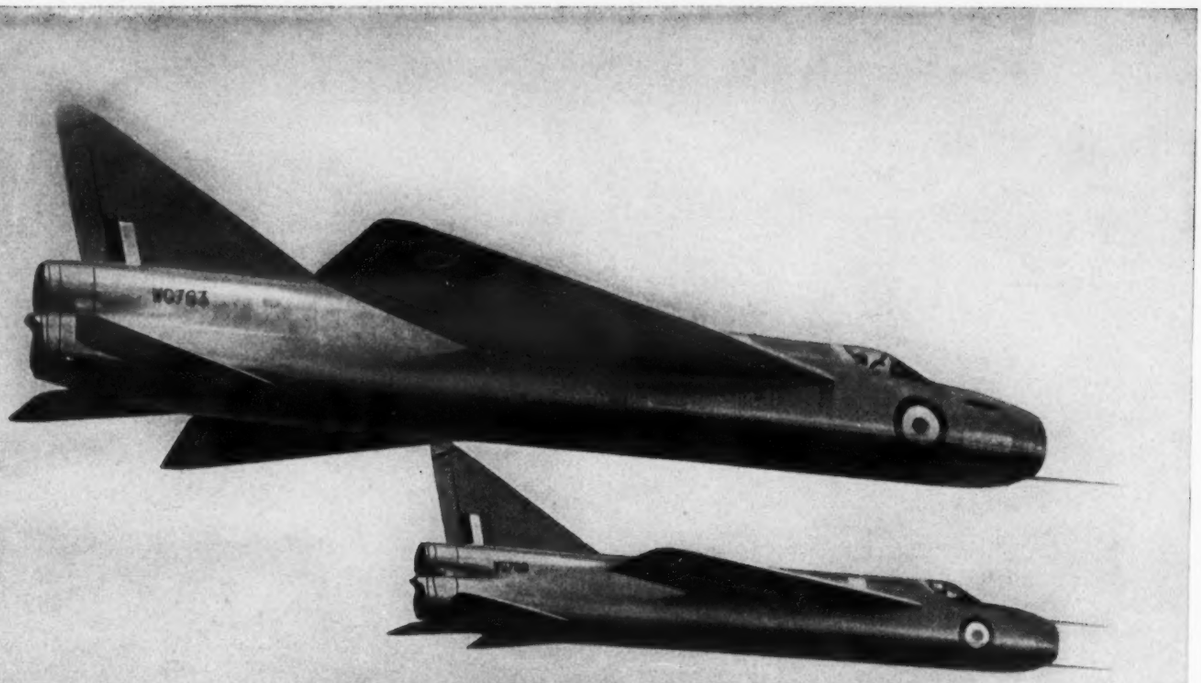
(on the fastest transcontinental passenger flight ever flown)

With a Lear Autopilot keeping a steady "hand" on the controls, the Boeing 707 prototype streaked across the country at speeds up to 692 m.p.h. So smooth was this record-breaking flight, so astonishingly free from vibration, pitch, roll or yaw, that a coin balanced on edge stood up without tottering. **LEAR**

LEAR, INCORPORATED, EXECUTIVE OFFICES, 3171 S. Bundy Drive, Santa Monica, California, U.S.A.

LEAR S.A., Aeroport, Geneva, Switzerland - LEAR ELECTRONIC GmbH, Flughafen, München, Germany

LP-16



FORETASTE OF TOMORROW

The English Electric P. 1, Britain's first fully supersonic fighter, is destined to follow present day fighters into squadron service with the R. A. F. and a production order for it has already been placed.

THE

'ENGLISH ELECTRIC'

P.1

'ENGLISH ELECTRIC'
aircraft

QUEENS HOUSE · KINGSWAY · LONDON · WC2

PARTNERS IN PROGRESS WITH MARCONI'S AND NAPIER IN THE ENGLISH ELECTRIC GROUP

The Bottleneck: Air Traffic Control

By Dipl. Ing. A. Fischer, Zürich
Air Traffic Control, Radio Switzerland

"Good weather! Hope I get good weather tomorrow!" sighed the airline pilot in the thirties. Rain and low cloud meant danger, meant painfully crawling along rivers and railway lines. Yet today we read in "Air Line Pilot" of the poor aircraft captain who curses the sun and longs for a sky full of cloud, because then he can creep under the sheltering wings of Air Traffic Control and runs no danger of colliding with a "VFR aircraft"; we hear him lament that he has lost confidence in the "see and be seen" principle and learn—not without astonishment—of his ultimate groan:

"Please Lord, let there be lousy weather tomorrow!"

We have come a very long way in the ground control of aircraft flying on instruments, in air traffic control, which keeps aircraft miles apart in space with the reliability (and the lack of imagination) of a machine. No more danger of collision like there used to be with visual flights! Navigation aids and communications systems, instrument approach and airport lighting systems are good, and our airways must become broad, straight and smooth pathways from one airport to another, on which air transport can glide safely and rapidly into the jet age!

Yet, somehow we rather doubt whether this rare bird (he—a pilot—should have said something good about Air Traffic Control?) was really serious in his plea for bad weather. If he was, then his is a lone voice crying in the wilderness. We would wager that his airline's operations manager has little use for bad weather, as it plays skittles with his turn-around plans; the finance minister curses it, as it costs him a mint of money; the advertising boss, because it makes nonsense of his finest slogan, "on time all the time", and the passengers . . . but then passengers are long-suffering people.

To put it briefly, bad weather still means delays, cancellations, waiting about, extra work and extra costs. And who is to blame for all this? Air Traffic Control, of course!

Air Traffic Control is the scapegoat for pretty well everything that is not quite as it should be in air transport. The pessimists forecast its early breakdown, when the two hundred jet aircraft now on order begin to sing their four-part song of high fuel consumption. For these latest darlings of the airlines—as a I.A.T.A. panel has recently discovered—must at all costs climb as quickly as possible to their cruising altitude, must at all costs be able to keep to their most economic altitude (apparently the same for all of them) and must at all costs be able to descend and land at their airport of destination without delay. But definitely.

All of which reminds us of the Chicago fire brigade racing through the red traffic lights in the rush hour, with sirens screaming. The resulting traffic chaos is then—of course—the fault of the traffic police.

Joking apart, however, the whole technique and system of air traffic control are threatening to fall behind the rapid growth in air traffic, thus becoming a bottleneck.

The principle on which aircraft flying blind in the clouds are directed by ground control and safely guided past each other is relatively

Aircraft are under the care of Air Traffic Control from take-off to landing. After take-off, for which the control tower (left) is responsible, the aircraft is passed on to airways control (right) and instructed to report when over set points. Airways control keeps a record of all aircraft movements by means of a Flight Progress Board (rear) and checks them on the radar (scope in foreground).

simple: each aircraft reports its arrival over given points, such as MF radio beacons, VOR beacons or other navigation aids, to a central ground station, which in turn sees to it that no other aircraft flying at the same altitude passes over the reporting point within 10 minutes. This means that not more than six aircraft an hour can fly along a given route at the same altitude. It is readily understandable that even on moderately busy airways this number is not sufficient, especially since, at the world's major airports, an aircraft lands or takes off on an average every minute and a half throughout the day.

Here there are two possible solutions: to spread the traffic over several different altitudes, or to provide broader or parallel airways. Let us first examine the question of altitude. When a given altitude is already fully occupied, the next available level is 2,000 ft. higher (as aircraft flying in the opposite direction are already using the level 1,000 ft. higher), and after that it is 4,000 ft. higher. And that, as a rule, is as far as Air Traffic Control can go in allocating altitudes, as, for various reasons, pilots refuse to accept others. One, flying an unpressurized aircraft, cannot go higher for fear his passengers suffer from oxygen shortage, and cannot take the altitude 2,000 ft. lower because of the mountain peaks; another, with pressure cabin, must have the altitude which is most economical from the fuel consumption point of view, or declines the higher level because the headwind there is too strong; yet another, who has only a short hop to his next airport, does not want to climb too high anyway. In one case the minimum safe height is pushed up by army gunnery practice; in another, the maximum altitude is reduced because of fighter exercises above. In brief, the number of altitudes available to Air Traffic Control is more limited than might be believed.

Even if, in isolated cases, Air Traffic Control does succeed in spreading heavy traffic over several different altitudes, the result is of doubtful value, since the whole lot has to be brought down to a one-runway airport at the end of the trip, with one aircraft neatly following the other, like traffic on a three-lane highway which ends up at a city gateway 15 ft. wide.

But I can hear many readers murmuring: 10 minutes separation over a reporting point, what extravagance! Surely one minute would be enough, and then you could have ten times the traffic passing along the same route. These readers are fundamentally right; they have put

This high-precision gyroscope, on which directional gyro navigation and inertial navigation are based, is no bigger than a grapefruit. Picture shows C. W. Perelle, President of American Bosch Arma Corporation, recommending it with a confident smile for use in manned and unmanned aircraft.

their fingers on a vital point, the connection between Air Traffic Control and accuracy of navigation aids. Here lies the trouble: our navigation aids today are too inaccurate and too incomplete. There is a radio beacon or a VOR station, over which a pilot must fly in order to know his exact position, perhaps every 60 to 120 miles. But so much time can be lost or gained in between the beacons that aircraft which are neatly separated by 10 minutes over one reporting point may be dangerously close together by the time they reach the next one. Much better not change the 10 minutes safety margin; it has proved its value in practice.

Increasing the capacity of an airway thus means first and foremost *improving the accuracy of navigation aids*. The gaps between reporting points must be filled in, VOR stations supplemented by *Distance Measuring Equipment*. Much is, of course, already being done in this direction. The system most in favour today is the American VORTAC (VOR bearings combined with TACAN DME) or pure TACAN. Slightly less prominently advocated is the British *Decca* system, based on the principle of hyperbolic curves, which also permits very accurate navigation.

What is the position, however, over the Atlantic, where short-distance navigation aids cannot be provided? The same problem arises here. At every hour of the day and night something like 35 aircraft are shuttling in both directions between the British Isles and Newfoundland. Each must be separated from the next by 30 minutes in time, 120 nautical miles laterally and 2,000 ft. in altitude—the standards necessitated by present navigation accuracy. *Consol* is merely a position line system, *Loran* covers the North Atlantic only under very favourable propagation conditions, and shooting the stars may have been quick enough for Christopher Columbus' caravels but is less suitable for today's caravels of the air. With all three systems the navigator, carried along solely for this purpose, can get a fix every 30 to 45 minutes—if he works hard.

It might well be thought that there is plenty of room over the Atlantic for as many aircraft as are wanted, provided one flies a little further north, another further south, one lower, one higher. After all, there are no military areas here, no mountains, no political frontiers. All true on the one hand, but it is particularly on these long overseas routes that every aircraft must aim at economical fuel consumption, which means, by and large, avoiding the strongest headwinds, utilizing the strongest following winds, sticking to an economic altitude. Since all aircraft today are more or less similar, this means in turn practically the same course and the same altitude for all. Here too, then, problem number one in attaining smoother, denser

In the "inferno" of a busy Air Traffic Control centre (New York-Idlewild).

Atlantic traffic is to improve navigation systems. While *Navaglobe* and *Navarho* are still in a stage of uncertainty, a new star has recently appeared on the horizon in the shape of *Dectra,* the long-distance version of Decca. Will it be able to provide the long-sought "10-mile accuracy at a glance" in mid-Atlantic?

Higher navigation accuracy over the oceans is also being sought by other means, with the aid of instruments which determine an aircraft's *movements* in relation to a fixed point, such as his airport of departure. One method is based on the inertial principle and uses gyroscopes, pendulum and accelerometers; another utilizes the doppler effect on radar pulses transmitted from the aircraft towards the ground, where the frequency of the returning echo varies according to the speed and direction of the aircraft.

Both lines of development can profitably be pursued side by side, since the systems of relative navigation can, at worst, form a valuable supplement to systems requiring ground aids.

But let us return to land and pay a visit to the "inferno" of a busy air traffic control centre. Externally "inferno" is by no means a bad description, since an eerie twilight reigns in the windowless room, broken by the pale light from dozens of blue-green or orange radar scopes.

Where would Air Traffic Control be today without radar? Radar is the magic eye with which Air Traffic Control can *see* the aircraft for whose safety it is responsible, through night, cloud or rain. Radar gives us the exact position of aircraft within the range of its stations and thus closes the gaps between the reporting points. Hence, it might be thought, there is nothing to stop us from drastically cutting the 10-minute separation interval or, in terms of long measures, reducing the distance between two aircraft flying at the same altitude from 50 miles to some 3 miles, a distance which can still be clearly detected on a radar scope.

Since the philosopher's stone appears to have been found, why continue the search for more accurate navigation systems, why plan to invest still more millions in TACAN and VOR-DME?

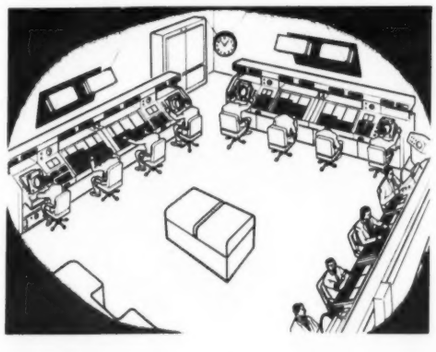
Because, although it is of inestimable aid, radar is not a universal panacea. Above all, it has one big disadvantage as a navigation aid: an aircraft crew cannot determine its own position by radar, but needs the assistance of a manned ground station; the aircraft cannot move independently with the desired precision, but must be guided. The system thus in a sense resembles the old ground-to-air D/F procedure, which rapidly broke down as traffic density increased and had to be replaced by the radio compass.

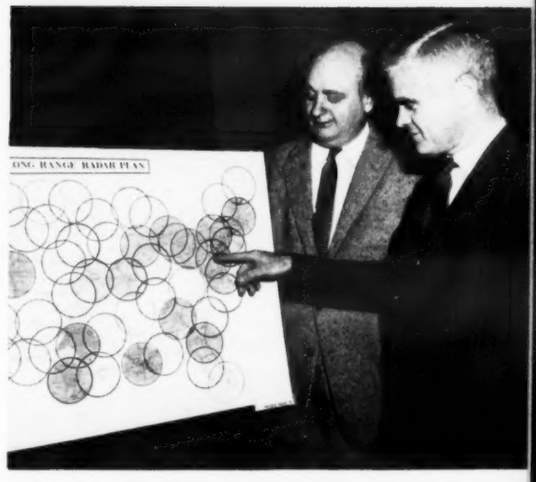
A single ground controller can, if he is very skilful, "guide" 3 to 4 aircraft at once by R/T, but not more. He can, however, "supervise" a larger number, since he then has to deal, at any given time, with only one aircraft that is out of step. It is clear, therefore, that radar is an excellent instrument for *surveillance* purposes, but is of only limited value as a *navigation system.*

Despite these practical limitations, radar cover of the controlled air space is the *only effective means,* in the present situation of inadequate navigation accuracy, of speeding up the flow of traffic. Thanks to the constant check it provides on the safety distance between one aircraft and the next, this distance can be reduced to 3 nautical miles, at any rate near critical traffic centres. This is already done, for example, in the immediate neighbourhood of all busy airports, thus enabling 40 to 50 take-offs and landings to be made in an hour, a figure that would have been unthinkable a few years ago. The further radar control extends over the airways, the sooner Air Traffic Control can intervene, organize the traffic flow, arrange the aircraft in order and create the most favourable situation to ensure a smooth landing sequence.

This is one of the reasons why most countries are today aiming at extending radar cover to the controlled airways. The example of the Canadian radar chain, which is to stretch right across the country, is already known, and the United States are planning a network of no fewer than 73 stations with ranges of around 130 nautical miles; to provide far-reaching

Communications between the individual controllers and sectors has become the planner's nightmare: view of the "Centre de Contrôle Régional Nord," Paris-Orly.





In the present state of affairs radar is the only effective means of speeding up traffic flow: James T. Pyle, U.S. Civil Aeronautics Administrator (right), and J. H. Tippets, Director of C.A.A.'s Federal Airways division, in front of the general plan of America's air transport radar stations which are being built by General Electric and Raytheon.

cover for the airways. In Europe, the very good radar cover of Southeast England is a prime example.

Needless to say, the value of radar cover lies not only in reduced separation standards between aircraft, but also in the smaller *danger of collision despite the reduced distances.* Indeed, with so wonderful an instrument as radar to hand, it is tempting to abolish altogether all VFR flying and insist that everything moving through the air should be controlled under Instrument Flight Rules. This would be a gigantic task, which nobody wishes to undertake at the moment, since it is just not feasible. Yet everyone realizes that something has to be done in the way of preventing collisions in good weather. Since the collision danger grows with the increasing speed of aircraft, and the fastest military and civil aircraft fly at the highest altitudes, the creation of *upper control areas* is being planned as a first step in both America and Europe. All flights would be controlled in these areas, which would thus become a pilot's paradise where nobody need watch out for his neighbour, since the ground control would take care of the separation between aircraft.

What then is so wrong with the Air Traffic Control System? We shall soon have more accurate navigation aids and more complete radar coverage; what then, is the trouble? The answer is, we discover, on closer examination, the seeming paradox that these moves towards improvement in traffic control spell the end of the present ATC system.

The radar controller sees the whole traffic compressed into a single horizontal plane . . . When are we going to get the promised secondary radar that can identify aircraft and indicate their altitude?

In many places today's control system has already reached the limits of its capacity, and it is not difficult to imagine the outcome when traffic flow on the airways has been multiplied fivefold through better navigation aids and has become faster and still more varied through the introduction of jet transports.

Here it must be added that the method by which the control centres guide and control air traffic has not been changed in essentials for a long time. The airways controllers still note down the position and altitude reports received from aircraft on strips of paper, which are then arranged on the Flight Progress Board under the respective reporting points. From these strips controllers must calculate the estimated time of arrival over the next reporting point. The whole finally gives a constantly changing picture of the traffic situation, which must always be such that two aircraft never approach closer to one another than the separation rules allow. It is the air traffic controller's task to ensure that these conditions are met by passing R/T instructions to the aircraft.

A nice, efficient method, simple and not too straining, the reader may think. Quite . . . in the days when five aircraft an hour had to be passed over a given route.

But one day the controller discovered this number had grown to 20, he scarcely had time to catch his breath between aircraft, and his pencil got almost red hot from all the writing. Then "his" air space was chopped into two halves, two controllers were set down in front of two Flight Progress Boards, and two R/T frequencies were provided. Now each controller had only half the work—or rather, somewhat more than half, as the transition area between the two control sectors had to be carefully watched, and the two controllers had to *coordinate* their work.

But then traffic doubled again. Once more the number of sectors, R/T frequencies and controllers was doubled. By this time the task of coordinating had become so great that special additional coordinators had to be employed. Sector controllers could no longer sit side by side, which necessitated the introduction of an interphone system. Individual controllers, of course, lost their overall view of the traffic situation, and special supervisors became necessary.

Traffic became still denser and faster. Still more sectors? Still more splitting up? Perhaps the outgoing traffic from a major airport could be separated, from the control point of view, from the incoming traffic; this would not complicate the coordination task excessively. But this, of course, could be done only if the outbound controllers were given radar aids. Only then could they guide outgoing traffic on separate courses past the incoming aircraft until it reached cruising altitude. Next it was discovered that the outbound controllers could see nothing on their radar scopes in the daylight-lit control centres. So shut out the daylight and put lamps in front of the Flight Progress Boards!

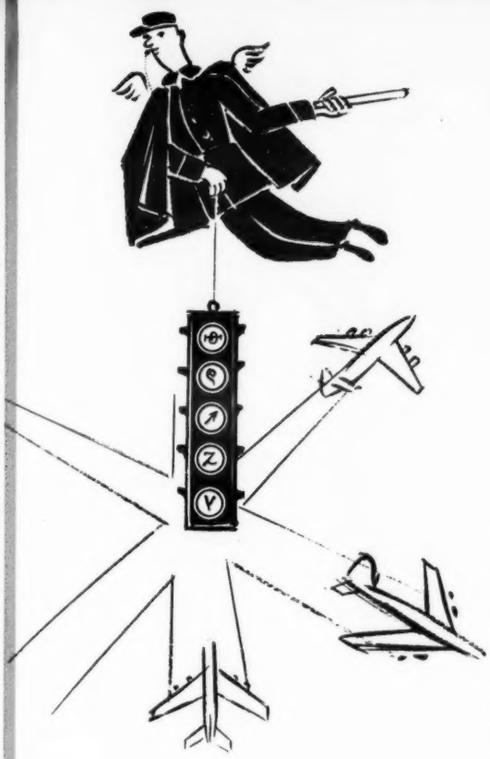
Still traffic went on increasing. Impossible to create more sectors. Already an aircraft approaching an airport must change its R/T frequency six times within the last 60 miles. Speech channels are overloaded, the traffic situation is increasingly difficult to survey, and the task of coordination more and more complicated. The only solution was to use more radar. Radar for each individual sector, with the longest possible range. But there is a slight flaw in radar operations. The radar controller sees the traffic displayed on a horizontal plane—his equipment is not called "Plan Position Indicator" without reason—he has no check on altitudes, and identifying aircraft is difficult (when is that secondary radar coming along?). Caution is therefore needed, so individual radar controllers are given only a few aircraft to handle at a time. And, as they have no overall view, the Flight Progress Boards must be kept on, and the general traffic situation must still be displayed. Radar is a wonderful aid, for special tasks, for the passive maintenance of small separation distances; but it does not replace anybody. On the contrary, still more staff has had to be taken on. Communications between the various types of controller and between the different sectors have become the planner's nightmare. Now there must be super-supervisors who, armed with headphones and eight-pin plugs, can cut into the interphone system whenever a critical situation arises.

But the traffic flow swells and swells. The centre responsible for controlling it in a busy area has become a witches' cauldron. A dozen radar controllers struggle against the disturbing light from the Flight Progress Boards, while the other three dozen controllers curse the semi-darkness in which they can scarcely read their notes. Thirty or forty voices all talk into the microphone at once, producing a ghostly murmur in the soundproofed room. Three or four hands write simultaneously, on hundreds of strips of paper, mysterious hieroglyphics denoting altitude, position times, ETA over the next reporting point. Lamps flash on: the interphone line to the neighbouring centre 600 miles away is engaged by sector 10; wait . . . "Stand by, TWA Flight 970, stand by please". Now the red "engaged" lamp for the interphone line to the neighbouring sector also lights up. The operator jumps up and runs to Board 4 to check that B.O.A.C. Flight 200 has really passed over "Mike Bravo". Quick, back to the desk, slip on the headphones again, push over the microphone switch. "Army Flight 7683, you are cleared . . ." Attention! Fog is drifting up on the New York airports; prepare to detour fifty approaching aircraft to Boston or Washington . . . The airways there are congested? "O. K. boys, get things straightened out, but quick!"

But the airlines' "jet darlings" must at all costs—the I.A.T.A. panel has just decided—be allowed to take off and land without delay.

Air Traffic Control is expected to handle all aircraft not only safely but also expeditiously. This means that the many-headed, many-armed creature that is the control centre must, if it is to disentangle a traffic situation in the shortest possible time, find not just any solution, but the *best* safe solution.

Well, electronic computers are used for much simpler tasks. The pressing need is for more accurate navigation, a reduction in voice communications, a move away from "hand work" in the control centres to automation.



TACAN
combines Accurate Navigation with Strict Airspace Control

After seemingly endless discussions on the parallel use of VOR and TACAN, the two navigation aids for medium distances were last year combined to form a common military and civil system known as VORTAC. The steps already taken by the U.S. Civil Aeronautics Administration and the Defense Department towards the implementation of the VORTAC programme represent real progress in the field of air safety, since TACAN and VORTAC provide the pilot with extremely accurate and reliable azimuth and distance data. *

Accurate navigation by the pilot, however, is not enough. To prevent collisions and to control air traffic in the neighbourhood of airports, the control centres on the ground must have reliable information on the identity, position, altitude, speed and course of all aircraft in their areas. For these tasks the TACAN system has been provided with an additional equipment, the TACAN Data Link. Developed under the sponsorship of the U.S. Navy by the Federal Telecommunication Laboratories, a division of International Telephone and Telegraph Corporation, the new air traffic control system is now undergoing military operational trials. The first releases issued thus confirm earlier assumptions that TACAN was designed *from the outset as an integrated navigation and air traffic control system.*

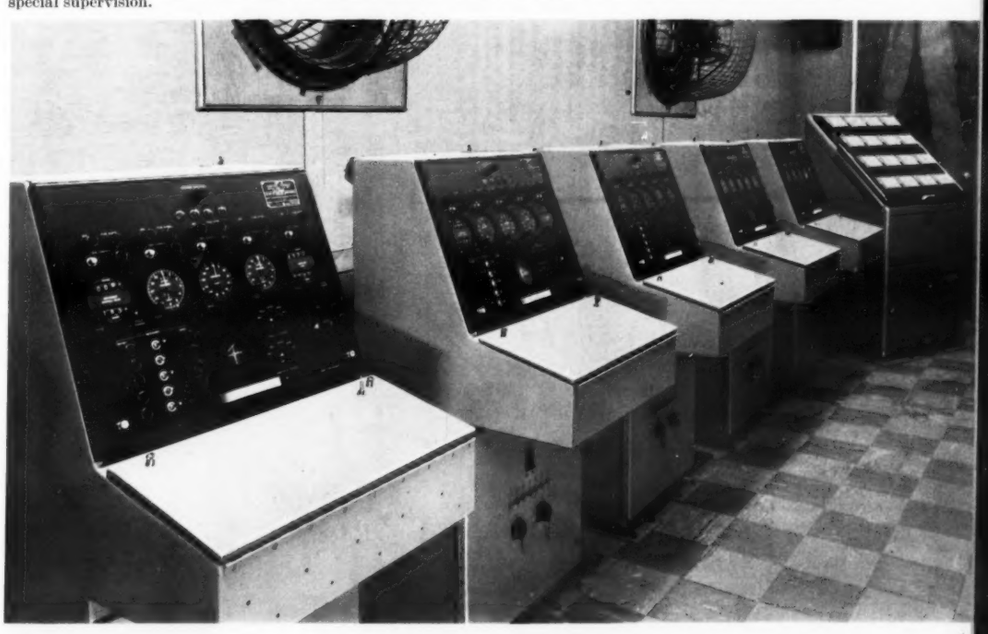
According to FTL President *Henri G. Busignies,* the TACAN Data Link enables most of the delays in air traffic control to be eliminated and solves some of the problems involved in the introduction of jet transports. Complex traffic situations can be handled with ease, since the ground/air exchange of comprehensive information on identity, speed, course, altitude and position of up to 120 aircraft takes only about six seconds. In future, the ground controller will always know where aircraft really are and what they are doing, whereas in the past he has received information only on where they *were* and what they *were doing* some time before.

The services of the TACAN Data Link are available as soon as the airborne TACAN or VOR equipment is supplemented by a small additional device. To avoid overloading the instrument panel, readings of bearing, distance, course, speed and altitude are combined in dual-purpose instruments with the instructions transmitted from the ground, so that the pilot simultaneously receives both his actual situation and that ordered by the ground station.

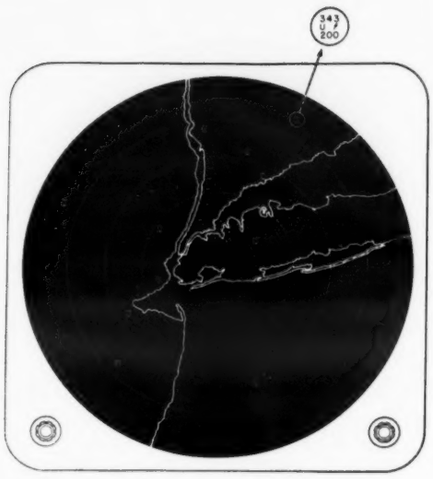
Pilot and ground controller can also exchange routine messages by means of a push-button arrangement in the aircraft and the control centre, each having at his command a "library" of 31 messages. If, for example, the ground controller wishes to instruct the pilot to let down his undercarriage or continue his flight, he simply pushes the appropriate button, and the order appears in word form on the pilot's instrument. Similarly, the pilot can tell the ground station that he wishes to land or is awaiting instructions, etc. As each message arrives, a signal calls it to the pilot's attention. The pilot acknowledges an order by pushing the appropriate button.

One big advantage of the system is that it removes language difficulties on international routes. Though most pilots and ground controllers speak two languages, misunderstandings can easily arise under

Five control and display desks and an assignment board for 16 aircraft (far rear) form a "control and display group." Each desk indicates identity, position, speed, altitude and heading of a single aircraft, in cases where the latter requires special supervision.



* cf. *Interavia* No. 10, 1956: "The TACAN System and the Results of the Alaska Tests."



The display scope of the combined TACAN Data Link ground equipment shows the controller in each "position circle" the identity, heading (arrow) and altitude (e.g., in hundreds of feet) of the aircraft concerned.

difficult conditions through noise, distortion and language colloquialisms. With the new TACAN Data Link, the message appears in written form in a small window and can be in English in one aircraft, French, German or Japanese in another. In all cases the actual radio signal remains the same.

Thus the extended TACAN system should create a new balance between navigation and ground/air communications. As mentioned earlier, pilots already have accurate navigation aids at their disposal, but frequently come up against technical difficulties in transmitting their position reports, etc. Their communications system with the ground resembles the old party line telephone, as the pilot has to wait until a frequency that is also used by other aircraft is free.

*

Today's heavy air traffic definitely needs strict control by ground stations and a rapid system of automatically transmitting the required instructions to the pilot. Surveillance radar has already greatly simplified the ground controller's task, but this aid remains incomplete as long as the controller cannot immediately identify the aircraft represented by the blips on the scope. At present the controller must watch the blips for some time and maintain voice communication with the pilot in order to ascertain course and speed. Furthermore, it takes a separate radar to determine altitude in cases where the controller is not satisfied with the altitude figure supplied by the pilot.

TACAN and its automatic Data Link also use radar techniques, but in such a way as to meet the requirements for identification and automatic data transmission. On the ground station's scope the radar blip is

THE TACAN DATA LINK

(From information supplied by the Technical Office, LMT, Paris)

The principle on which air traffic control messages are superimposed on a TACAN ground/air link is illustrated at the left below. A ground antenna broadcasts radio waves which contain a synchronization signal (pulse references for determining bearing) with a repetition rate of 135 c/s. Messages from air traffic control are superimposed on this synchronization signal, with the navigation pulses being replaced 45 times a second by coded communications pulse groups. Each of the latter contains a message for a given aircraft.

Each individual message contains, in a group width of approximately 3 milliseconds, the aircraft's identification signal, plus qualitative information and quantitative instructions (speed, altitude, course, bearing, distance).

On receiving the message, the aircraft concerned automatically transmits the data shown on its instruments (speed, altitude, etc.) to the ground station in similar coded pulses.

In this way the following qualitative and quantitative information is exchanged:

a) qualitative surface-to-air messages:

identification: 1,008 identifications available;
mode of control, such as traffic control, automatic approach, etc.;
31 discrete messages, such as "proceed," "wheels down," etc.;
5 new command signals, as indication of major change of control orders.

b) quantitative surface-to-air messages:

ordered distance: 0—20 or 0—200 miles scales;
ordered bearing: 0—360 degrees;
ordered altitude: 0—5,000 or 0—50,000 ft. scales;
ordered heading: 0—300 degrees;
ordered air speed: 0—650 knots.

c) qualitative air-to-surface messages:

identity: automatic, by time separation;
mode report: automatic feedback feature;
31 discrete messages, such as "holding," "landing," etc.;
5 acknowledgements in response to new commands.

d) quantitative air-to-surface messages:

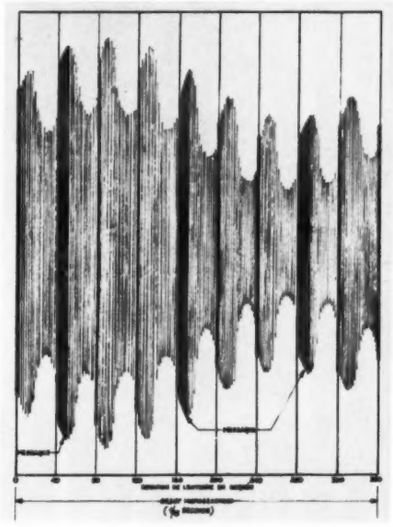
present distance: automatically encoded from TACAN DME; 0—20 or 0—200 miles scales;
present bearing: automatically encoded from TACAN bearing; 0—360 degrees;
present altitude: automatically encoded from pressure or radio altitude; 0—5,000 or 0—50,000 ft. scales;
present heading: automatically encoded from RMI; 0—360 degrees;
present air speed: automatically encoded; 0—650 knots.

The pulse groups for both transmission directions are formed of pulse pairs with the same qualities (form and interval) as the TACAN pulses, so that no extension of the frequency band is required. What is more, pairs of pulses are less sensitive to interference.

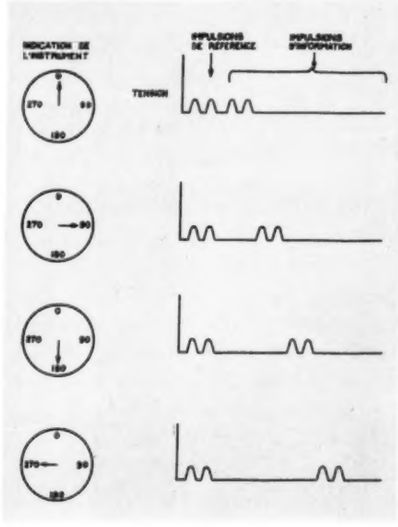
Pulse coding is selected according to the message to be transmitted. For quantitative messages, such as instrument readings, the interval between the pulse pairs is modulated. A typical example of this modulation is shown below right. For qualitative information (e.g. identification), on the other hand, digital pulse coding is used (varying combinations of several pulse pairs).

The superimposition of these pulse groups on the normal TACAN signal has no effect on the components which determine the bearing, as the reference pulses are not suppressed. Moreover, the time taken for the simultaneous transmission of these pulse groups to 120 aircraft does not exceed 10% of the total transmission time, so that distance measuring is maintained.

The broadcast signal of a TACAN antenna as received due south of the station; the envelope of the 15 c/s and 135 c/s modulation is used to determine bearing. The heavy vertical lines represent reference pulses at intervals of 40 degrees. Altogether 3,600 pairs of pulses are transmitted per second.



Example of an analogue or quantitative pulse coding of an instrument reading. The interval between a reference pulse pair *(impulsions de référence)* and a message pulse pair *(impulsions d'information)* is modulated in such a way that it provides a direct measure of the information to be transmitted *(indication de l'instrument)*.

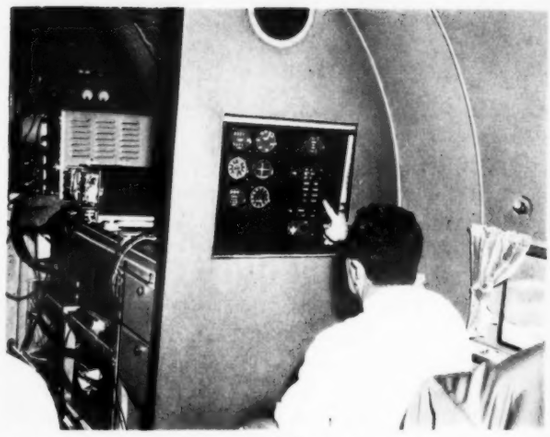


replaced by circles containing the following information; identification number of the aircraft or flight, an arrow indicating direction and—as required by the controller—altitude or speed. In this way the controller has all the information he requires for rapid decisions. He can either work out traffic control instructions himself or entrust this task to electronic computers.

All data, messages and orders are transmitted on the regular TACAN frequencies without hampering navigation, which promises considerable relief for the congested ground/air frequency band. The additional equipment for the TACAN Data Link contains no radio circuits and can be used with either TACAN or VORTAC.

*

Airborne instruments (on the pilot's instrument panel) and message selector unit (bottom right) for TACAN Data Link in a simple flight simulator.



Federal Telecommunication Laboratories has tested the airborne equipment for TACAN Data Link for 300 hours in this flying laboratory.

The technical details released at the beginning of March 1957 reveal TACAN'S main functions to be as follows:

—Continuous measurement of distance and azimuth in the aircraft and fully automatic reporting of azimuth, distance, speed, course, altitude and identity to the ground service, simultaneously for up to 120 aircraft within six seconds.

—Transmission of navigation orders from the ground to aircraft (simultaneously to up to 120 aircraft within six seconds) and display of these orders on the five main instruments in the aircraft.

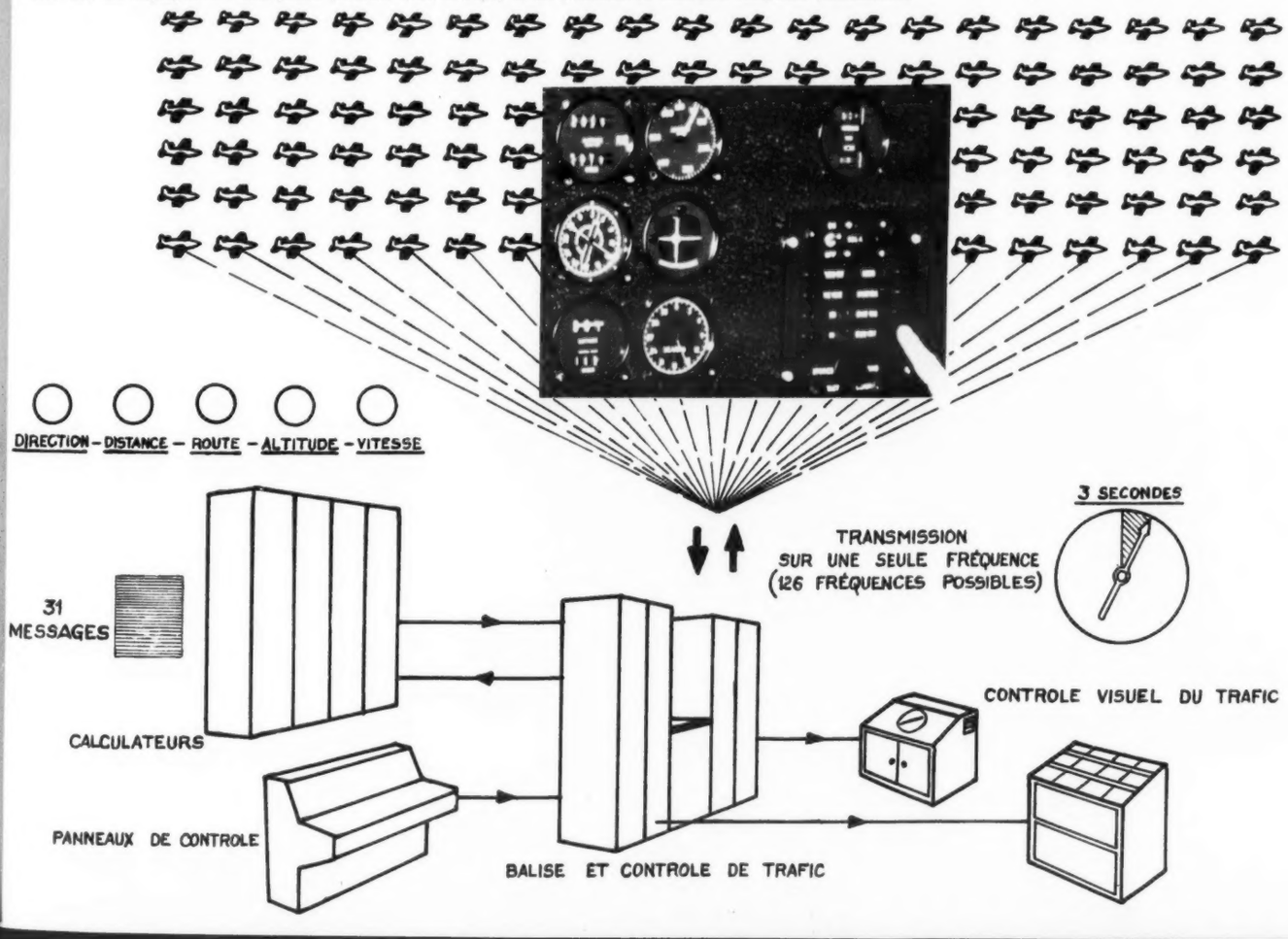
—Immediate transmission of up to 31 routine messages from ground to aircraft and *vice versa,* with confirmation. These messages are displayed at either end in written form, thus overcoming language difficulties. The system also reduces the load on the speech channels, since all transmissions are made on the UHF TACAN frequencies.

—Radar scope display, on the ground, of the traffic situation, including identification and altitude; air traffic control can also use electronic computers.

—TACAN airborne equipment can also be used for instrument landings (reception of localizer and glide path signals and continuous *distance measurement* with the aid of a TACAN-ILS ground station).

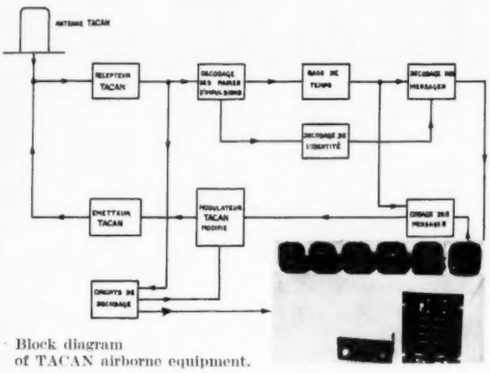
—TACAN and VORTAC equipment, at present used only for azimuth/distance or

TACAN Data Link transmits control orders (distance, bearing, altitude, heading and air speed), as well as 31 standard messages to up to 120 aircraft. The messages can either be selected by the ground controller on his control panel *(panneau de contrôle)* or be supplied by electronic computers. Similarly each of the 120 aircraft automatically transmits its actual bearing, distance, heading, altitude and speed, plus other information *(messages)* which the pilot selects from 31 standard messages, to the ground station, where they are displayed on visual panels *(contrôle visuel de trafic)* or are evaluated in electronic computers *(calculateurs)*.

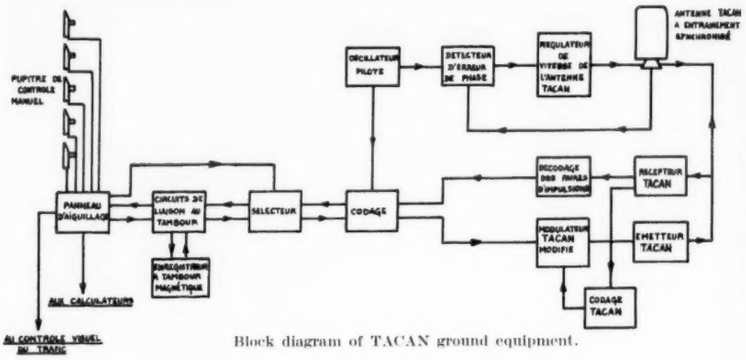


Airborne and Ground Equipment for TACAN Air Traffic Control Communications

(From information supplied by the Technical Office, LMT, Paris)



Block diagram of TACAN airborne equipment.



Block diagram of TACAN ground equipment.

The operating principles of the **TACAN** airborne equipment are illustrated in the block diagram at the left above. Signals arriving from the antenna are amplified in the receiver *(récepteur)* and passed on to the pulse pair decoder *(décodage des paires d'impulsions)*, where any interference is eliminated. The pulses then arrive at the time base *(base de temps)* and an identity decoder *(décodage de l'identité)*. The time base synchronizes an oscillator with the reference pulse group and thus provides a reference time for the coding and decoding of messages.

If the identity decoder recognizes the aircraft's allotted identification in the ground station's signals, it allows the rest of the message to pass on to the message decoder *(décodage des messages)*.

As soon as the signals from the message decoder reach the pilot's instruments, information destined for the ground station is conducted to the message coder *(codage des messages)*. The coded pulse groups are mixed in the modulator with the pulses to be transmitted for distance measuring purposes. After conversion into **UHF** pulses in the transmitter *(émetteur)*, the signals are emitted via the antenna.

*

In the design of the **TACAN** *ground equipment* special attention has been given to ensuring the widest possible application of the non-synchronized messages arriving from various sources (e.g., electronic computer, manual control desks, etc.). To achieve this, all information transmitted and received is stored on a magnetic memory drum.

The block diagram on the right above shows how the ground equipment works. An assignment board *(panneau d'aiguillage)* enables a given aircraft to be assigned to a given manual control desk for air traffic control purposes *(pupitre de contrôle manuel)* or to the appropriate electronic computers *(calculateurs)*. The messages to be sent to given aircraft are recorded on a memory drum *(enregistreur à tambour magnétique)*. At the same time the transmission frequency is recorded. The messages pass via selectors resembling automatic telephone dials to the coding units *(codage)*, whereupon the individual operating phases are synchronized by means of a crystal-controlled oscillator *(oscillateur pilote)*. The latter also controls the antenna's rotation, which necessitates a slight modification to the antenna drive and speed regulator *(régulateur de vitesse de l'antenne)* hitherto used.

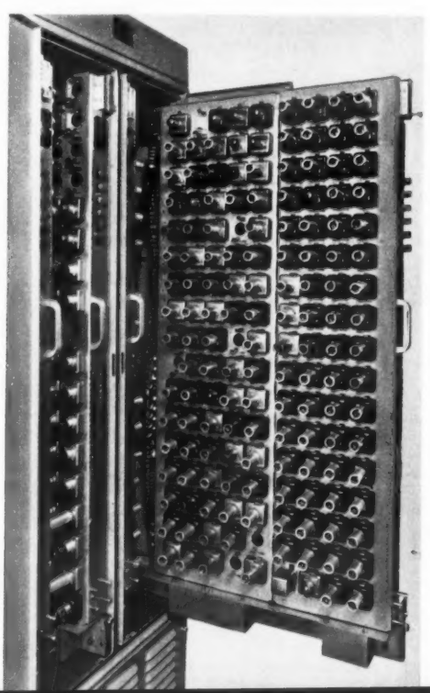
The surface-to-air message coming from the coding unit is mixed with the **TACAN** video signal and passes via the transmitter to the antenna.

Air-to-surface communications following immediately upon the surface-to-air transmission are detected in the receiver. The pulse pairs are decoded *(décodage des paires d'impulsions)* and pass via the selectors to the magnetic memory drum.

Immediately the air-to-surface message is recorded, the next surface-to-air message passes through the selectors to the coding unit. In this way 90 messages a second can be exchanged between aircraft and ground stations on each **TACAN** frequency (45 surface-to-air orders and 45 air-to-surface reports).

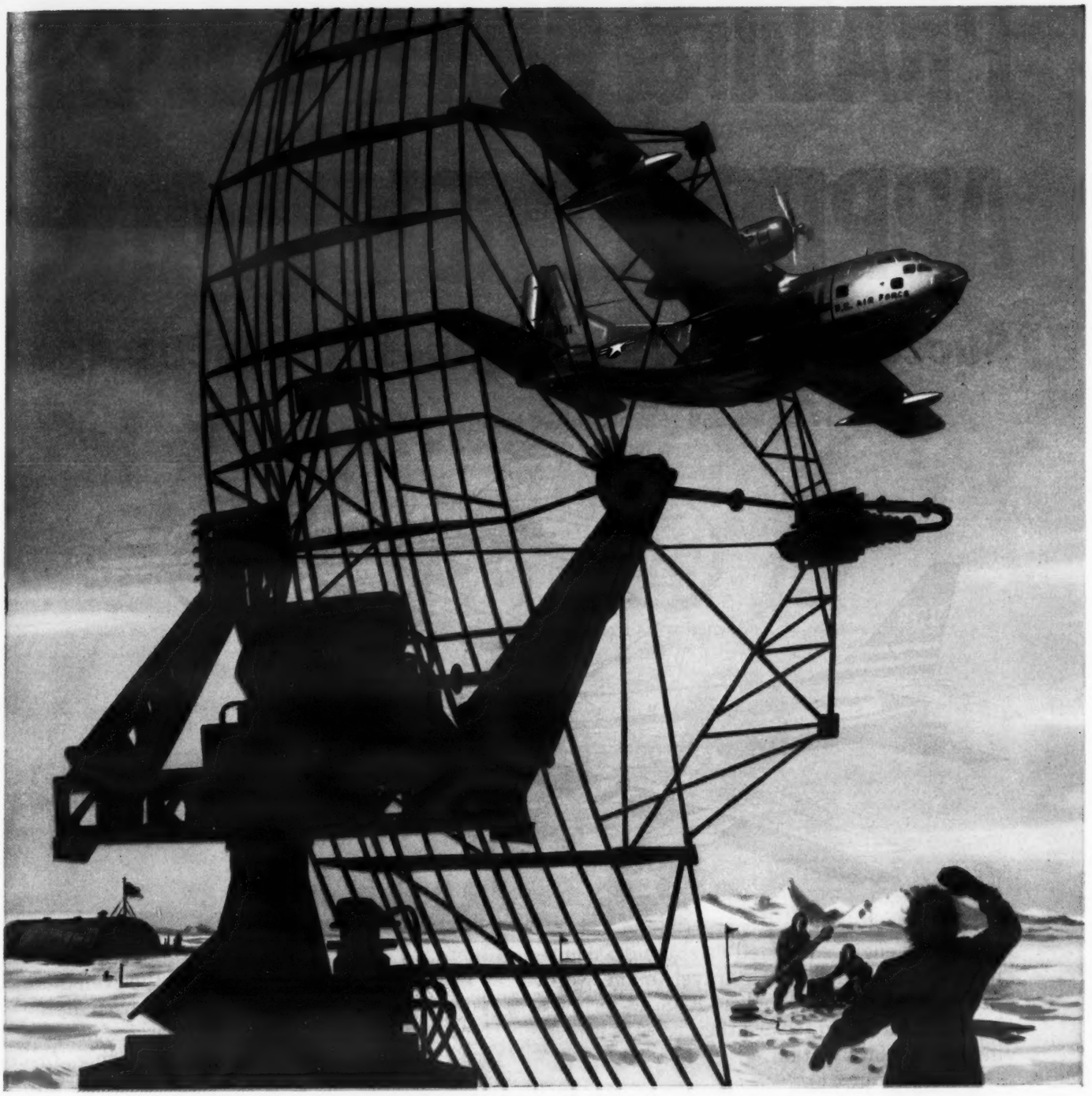
TACAN ground station with Data Link equipment. From front to back: power unit, receiver-transmitter, digital storage unit, coding unit and control unit.

Two of these cabinets code and decode the messages into digital or analogue pulse signals and vice versa.



pure distance measurement (in conjunction with VOR azimuth data), can be expanded by appropriate additional equipment to include other TACAN features.

How far these additional functions will later be available to civil aviation is not yet clear. The decision to introduce VORTAC, however, provides that civil airline aircraft in the United States will initially be able to use the distance measuring components of the military TACAN stations to supplement VOR. This would at last provide reliable navigation by polar coordinates. As, for physical reasons, the UHF TACAN system is much less sensitive to site influences than today's VHF VOR system, civil aviation may well advocate a complete conversion to TACAN within a few years.



The high frontier

Far to the north of settlements, roads and railways, DEW line outposts stand guard over America. They were built with the help of Fairchild C-123 transports, which flew in the men and the construction material—even the radar antennas which now scan the arctic skies.

The C-123 commuter service to the DEW line goes on at the rate of up to eight tons of cargo per plane—and at the end of the line the landing strips have proven too rough, too hazardous for any other heavy-duty transport now in service.

The members of this polar bear club have come to depend on the C-123—just as the U. S. Armed Forces everywhere. The C-123 shares these qualities with other Fairchild aircraft: ruggedness, reliability, and ever increasing utility.

FAIRCHILD

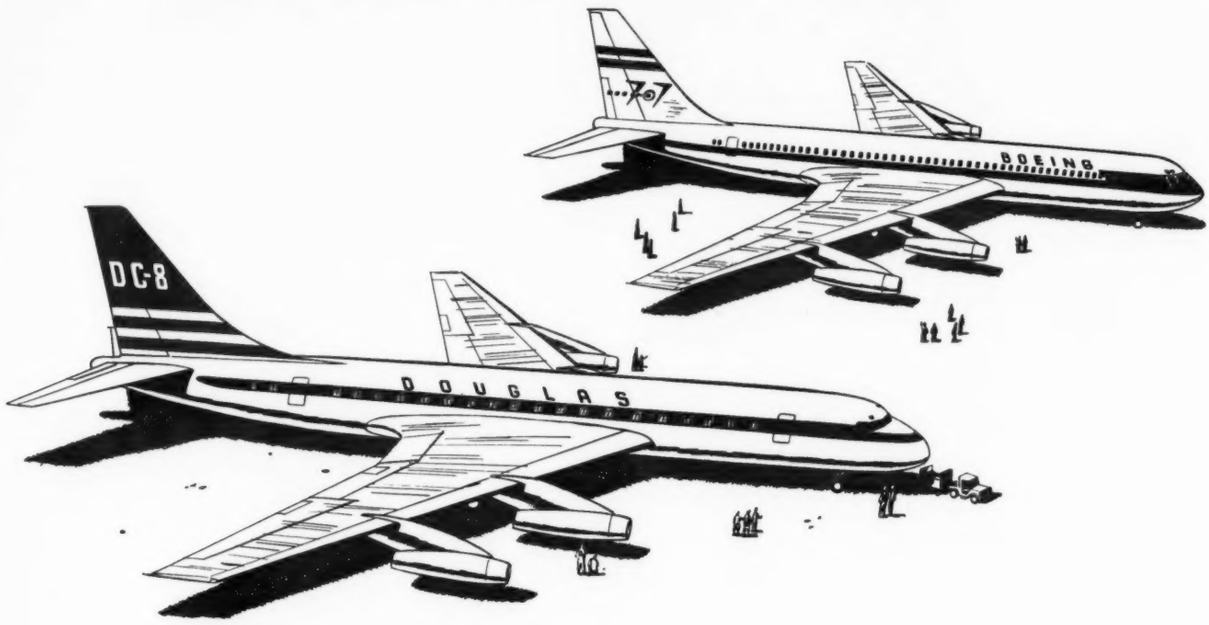
AIRCRAFT DIVISION • HAGERSTOWN 10, MARYLAND

A DIVISION OF FAIRCHILD ENGINE AND AIRPLANE CORPORATION

...WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!

PRATT & WHITNEY JET APPROVED BY C.A.A.

Success of U.S. Jet Engines Advances Age



The jet engines selected as standard equipment to introduce jet air travel to the world in Boeing 707 and Douglas DC-8 jet airliners have moved ahead toward their roles as leaders in commercial aviation.

On March 15, 1957, these engines—the Pratt & Whitney Aircraft JT3 and JT4—were certified for civil use by the U. S. Civil Aeronautics Administration. Behind the certification of these jet engines are many thousands of hours of the most exhaustive test stand and flight operations. The most powerful jet engines ever to receive this official certification, they are based on advanced engines powering the fastest U. S. fighters and bombers now in service.

The JT3 is the commercial version of the Pratt & Whitney Aircraft J-57, which has powered more aircraft at supersonic speeds than any other jet engine in production. The JT4 is the commercial version of the even more powerful J-75 engine, which has been flying for more than two years. Both engines provide high power coupled with outstanding fuel economy. By the time the jet airliners go into operation, the J-57 will have accumulated 4½ million operational hours. The J-75 is expected to reach 350,000 hours by the end of 1959.

The Boeing and Douglas transports these engines will power are now in production. Already more than 200 of these huge jet aircraft with Pratt & Whitney Aircraft engines have been ordered by 17 leading world airlines. They will enter service beginning in 1959, cutting flying times about in half, bringing the true age of jet air travel to people everywhere.

ENGINES OFFICIALLY FOR AIRLINE USE

of Jet Travel for All

These leading world airlines have ordered Boeing 707 and Douglas DC-8 transports with Pratt & Whitney Aircraft turbojet engines.

AIR FRANCE

JAPAN AIR LINES

KLM ROYAL DUTCH AIRLINES

QANTAS EMPIRE AIRWAYS

SABENA BELGIAN WORLD AIRLINES

SCANDINAVIAN AIRLINES SYSTEM

SWISSAIR

AMERICAN AIRLINES

BRANIFF INTERNATIONAL AIRWAYS

CONTINENTAL AIR LINES

DELTA AIR LINES

EASTERN AIR LINES

NATIONAL AIRLINES

PAN AMERICAN-GRACE AIRWAYS

PAN AMERICAN WORLD AIRWAYS

TRANS WORLD AIRLINES

UNITED AIR LINES

UNITED AIRCRAFT EXPORT CORPORATION *East Hartford 8, Connecticut, U. S. A.*

European Offices: *3/5* Warwick House Street, London SW1, England

Sylvania's bright new eye for pilots

Shrouded in rain and fog, 40 tons of plane and passengers are on the final approach of a runway which you can't even see . . . Speed, 110 MPH . . . Set her down or go around again? . . . 10 seconds to decide . . .

Suddenly, a streak of light cuts through the gray murk and rain, with the velocity of a comet and the timing of a heart beat . . . This is EFAS . cutting through that critical blind spot, pointing again and again to your runway.

EFAS is Sylvania's new Electronic Flashing Approach System of twenty-eight 30-million candle power, non-blinding strobeacons showing you the way. Already installed at Idlewild, N.Y., and Newark, N.J. the CAA, Airline Pilots Association and the Air Transport Association have approved of EFAS. As one leading airline pilot puts it, " It's the greatest contribution to air navigation since the radio range. "

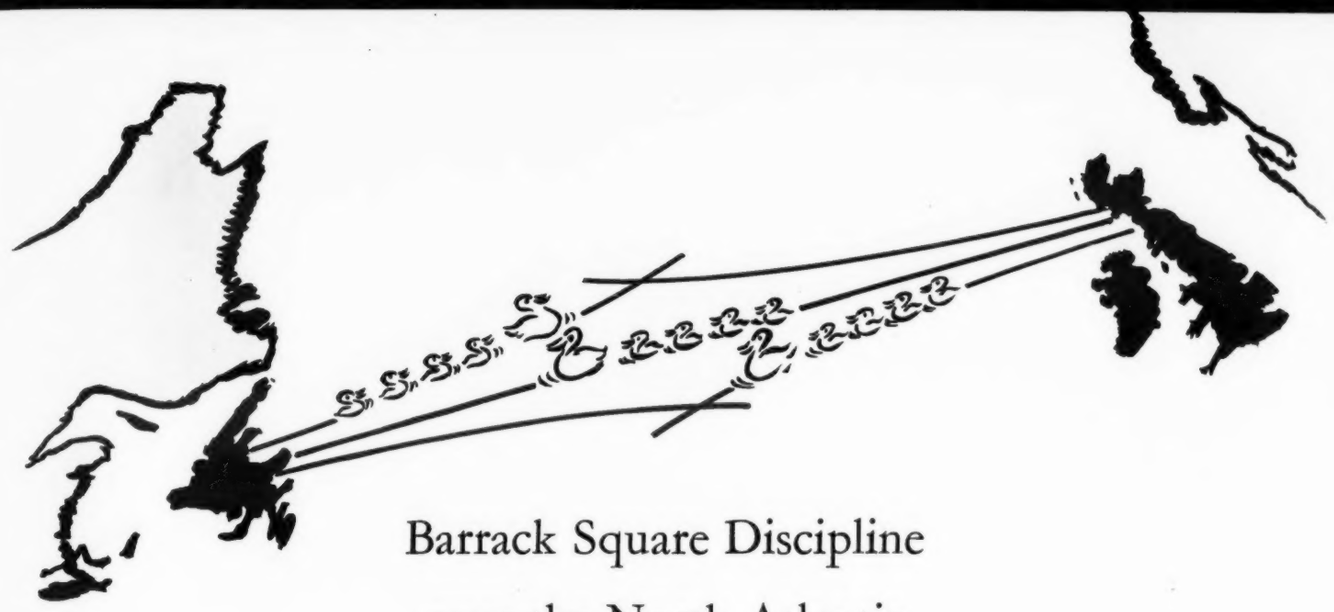
Sylvania engineers met the challenge for a better landing system with EFAS. Whatever your lighting problem may be, Sylvania engineering and forward-thinking " electronic lighting " can solve it for you. For the answers to ANY light-source problem, write to your Sylvania Distributor or to nearest address below:

SYLVANIA *International*

Western Hemisphere:
Sylvania International
1740 Brodway, New York 19, N.Y., USA

Eastern Hemisphere:
Sylvania International Corporation
22 Bahnhofstrasse, Coire, Switzerland

LIGHTING ELECTRONICS ATOMIC ENERGY
TELEVISION-RADIO PHOTOGRAPHY CHEMO-METALLURGY



Barrack Square Discipline over the North Atlantic

After long preparations a *Valiant* bomber took off from Prestwick airport, Scotland, at the beginning of April on the first phase of the practical testing of the Dectra navigation system*, which, it is hoped, will enable North Atlantic traffic to be speeded up and accurately controlled.

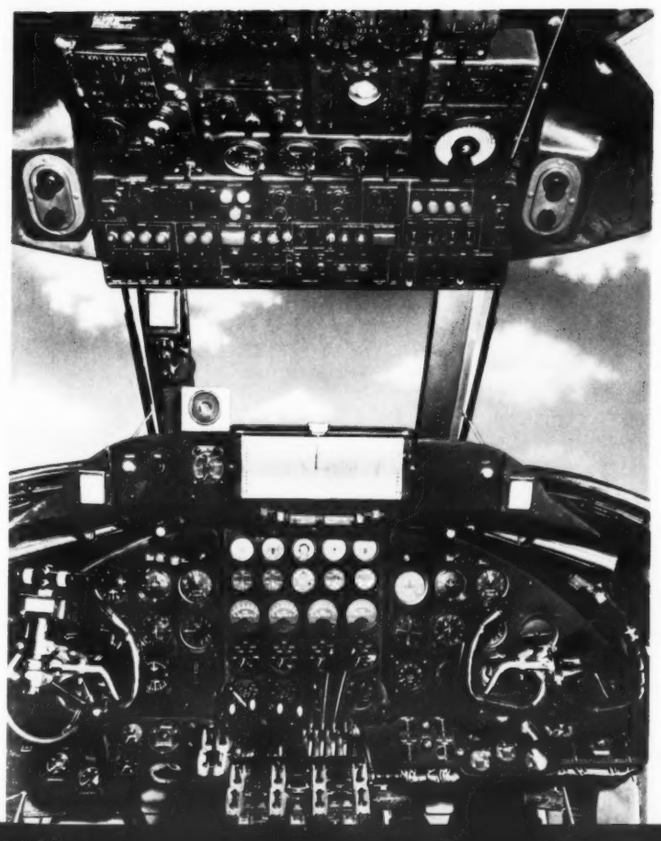
The test installation consists of a Master and a Slave station at either end of the airway connecting Prestwick, in Scotland, with Gander, in Newfoundland. The two pairs of transmitters cover the route with two hyperbolic patterns which meet in the centre and define so-called Deccatracks. An appropriate combination of the signals from the two Master stations also lays down a hyperbolic pattern across the route, which is used as a ranging reference (Deccarange). Under unfavourable propagation and reception conditions the signals from one station can be replaced, for ranging purposes, by the electromagnetic oscillations of a crystal oscillator aboard the aircraft.

As each of the two pairs of stations emits its "hyperbolic network" constantly, the pilot can switch his receiver to either pair as he wishes.

As the attached Dectra-Decca plan reveals, the Dectra stations are also used for Decca chains at either end of the North Atlantic route. When he reaches the terminal area, the pilot can thus switch his receiver to the normal Decca system if he so desires.

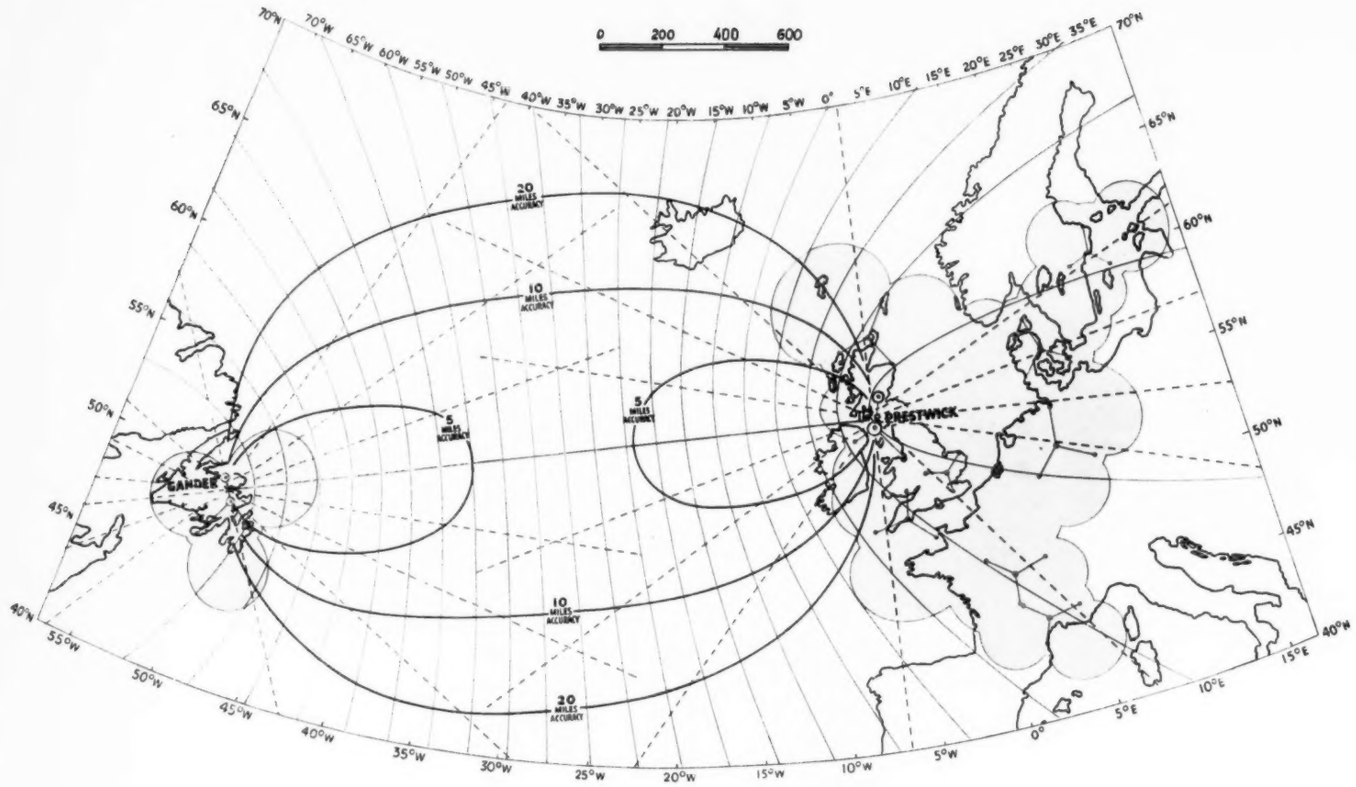
Presentation would normally be on a Flight Log installed in the cockpit, using a special map with a scale of 1 inch to 2 nautical miles at the ends of the route and 1 inch to 40 nautical miles in the centre of the route.

* *Interavia* No. 3, 1956 gave a detailed description of the projected Dectra navigation aid.



Left: The cockpit of a *Viscount 802*. Note the Decca Flight Log and, in the centre of the upper half of the picture, the Decometers for Red, Green and Purple.

Below: Dectra equipment Type 801 and the three Decometers for Red, Green and Purple.



Decca-Dectra plan for the Atlantic route between Prestwick, Scotland, and Gander, Newfoundland, and the adjacent areas (shaded). Roughly every hundredth tracking line and every hundredth ranging line is marked. The Dectra transmitters are also used as Decca stations.

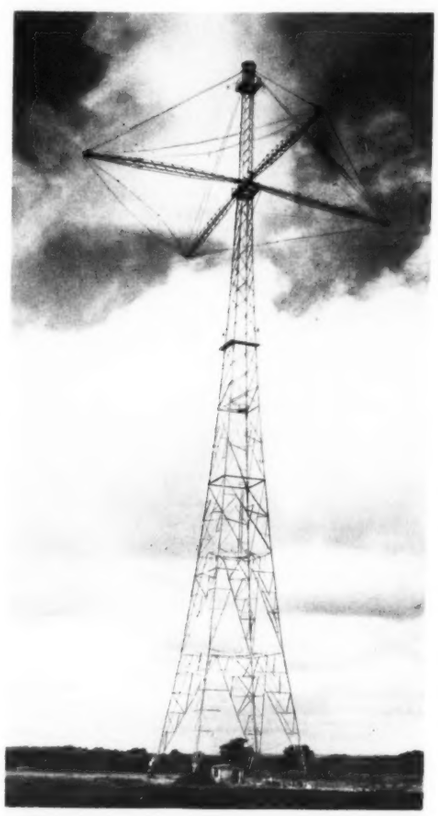
If preferred, data can be displayed on meters, namely the Deccarange meter which shows the distance to go to the station ahead, and a Decca-track meter showing lateral displacement from track.

*

The aircraft used for this searching test of the new Dectra system are a *Valiant* bomber belonging to the British Ministry of Transport and Civil Aviation and a similar aircraft—type not specified—from the Canadian Department of Transport. The tests are to last six months and are designed to provide confirmation of forecasts relating to reliability and accuracy of the system. Decca also plans to use its own aircraft for long-distance tests over the Atlantic. A number of weather ships equipped with Dectra instruments and other ships plying the Atlantic route are also taking part in the tests.

The interest shown in the experiments by B.O.A.C., Swissair, K.L.M., S.A.S., P.A.A. and T.C.A. underlines the urgent need for the introduction of an accurate, adaptable navigation system on the North Atlantic route.

A 600-ft. transmitter mast for the Decca-Dectra system.



At the present time up to 3,000 trans-Atlantic flights are recorded every month. This means that at any hour of the day or night there are roughly 35 commercial aircraft in the air between Newfoundland and the coasts of the British Isles. With conventional navigation systems lateral separation on the air routes must be 120 nautical miles, while aircraft flying on the same route must have an altitude separation of 2,000 ft. and a horizontal separation of 30 minutes.

If the practical tests of the Dectra navigation system confirm the theoretical forecasts, the above-mentioned safety standards can be expected to fall to the following values: lateral separation 30 nautical miles and longitudinal separation of 10 minutes for aircraft on the same course and at the same altitude.

Such "barrack square discipline" over the North Atlantic would appear to be the best method of reducing waiting periods on the ground (before take-off) and in the air (before landing) and avoiding unpopular detours and flights at uneconomical altitudes. All this will be of particular value in the jet age.

The mobile equipment for the Bell automatic landing system, for use on either airfields or aircraft carriers.

The radar antenna can be set up separately from the trailer.

An Automatic Landing System

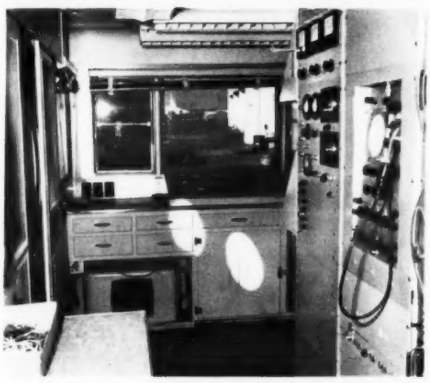
Bell Aircraft Corporation of Buffalo, New York, has developed for the U.S. Navy a fully automatic landing system which enables aircraft to land safely regardless of visibility conditions. Under this system the pilot does not take over control again until after touchdown.

The basic units of the readily mobile installation—a radar set and an electronic computer—can be erected either at land airfields or aboard aircraft carriers.

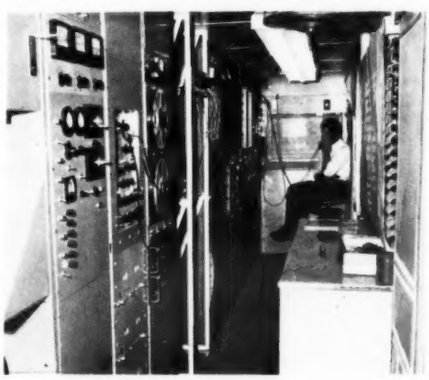
The pilot steers his aircraft to the vicinity of the runway or the carrier (to within a few miles) by means of conventional navigation aids, after which all further procedures are taken over automatically by the ground installation. The radar determines the aircraft's position, altitude, course and speed, and the electronic computer compares these data with the standards for optimum landing approach stored in a memory drum. Any corrections revealed to be necessary are transmitted in the form of radio signals to an automatic control system aboard the aircraft. For a landing on a carrier deck, the latter's pitch and roll motions at the moment of touchdown are also allowed for. If the aircraft is approaching in such a manner as to make a safe landing appear doubtful, it is automatically waved off.

During tests of the landing system on land bases, more than 1,200 fully automatic landings have been made by jet fighters, military and commercial transports at a number of different airfields and in all types of weather. Tests with a normal rate of descent (2 ft./sec) revealed a landing precision of $\pm$ 10 ft. laterally and $\pm$ 100 ft. in the landing direction. For higher rates of descent (9 ft./sec) longitudinal precision was $\pm$ 22 ft.

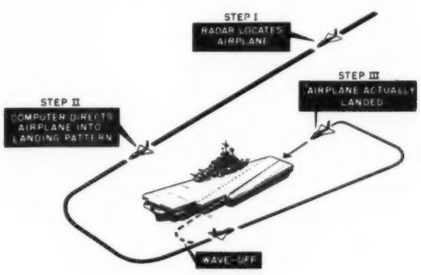
The automatic landing system enables aircraft to land safely not only in conditions of bad visibility, but also in cases where the pilot is hampered by wounds or fatigue. It can thus be expected to contribute substantially towards increased safety in both military and civil flying.



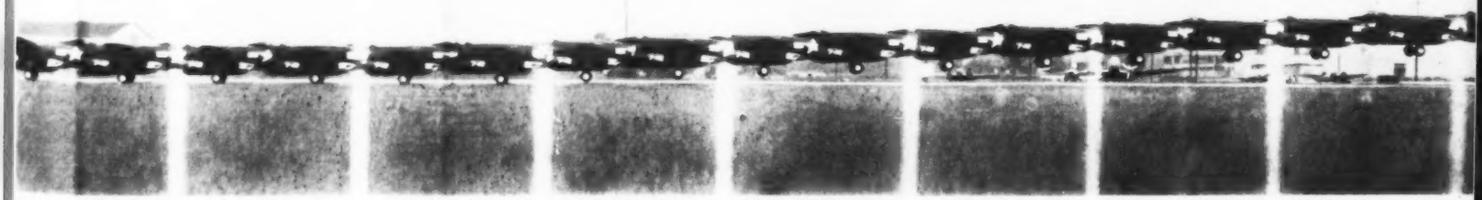
General interior of the trailer for the carrier landing system.



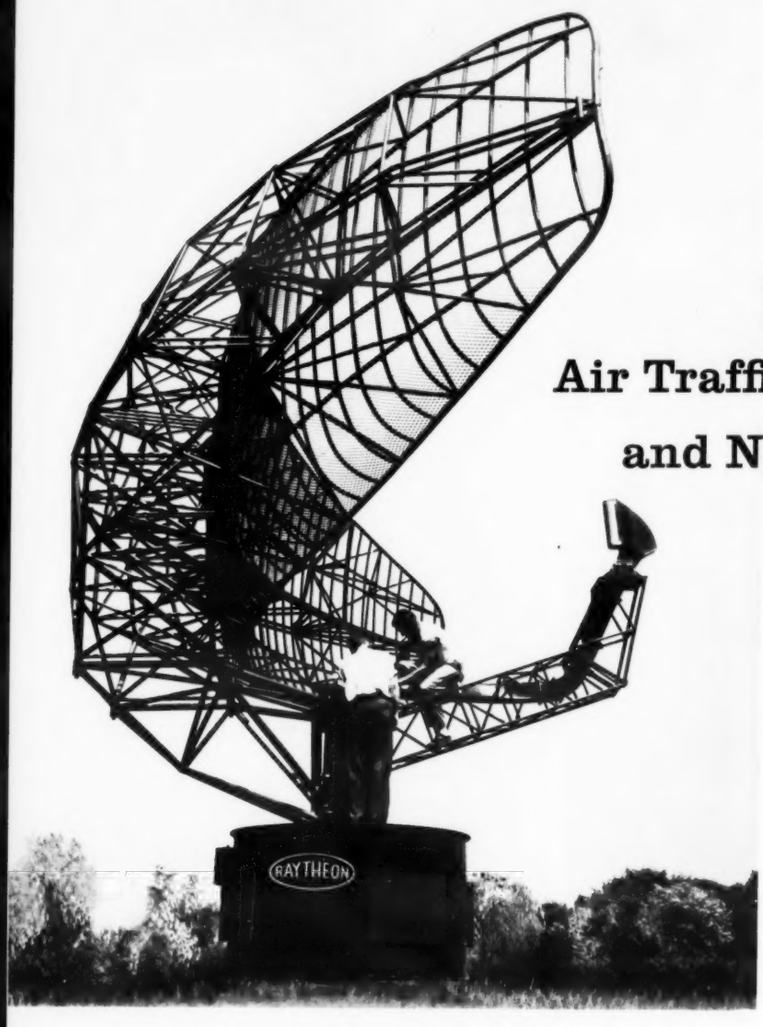
A radar locates the aircraft, and an electronic computer sends course corrections to a device in the aircraft which automatically directs it into the desired flight path.



A U.S. Navy aircraft making an automatically controlled landing.



Radar for Air Traffic Control and Navigation



The antenna of this Raytheon search radar, used in the United States for air traffic control, is 40 ft. across; maximum range 200 miles.

Air Traffic Control and air navigation can no longer be imagined without radar. Whether it is a question of airways surveillance, instrument landings, storm warning or navigation problems, radar eyes provide a clear picture. They penetrate night, fog, clouds and rain; for them it is always daylight.

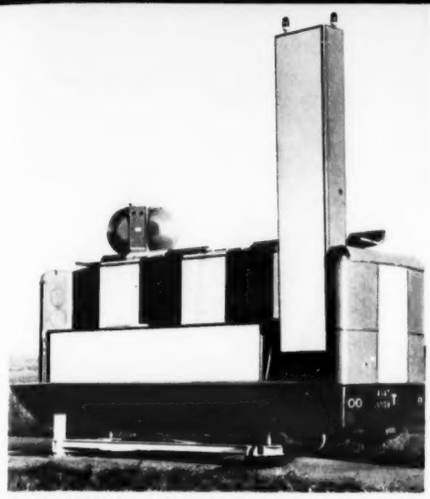
How do these radar eyes see in the pitch dark? Firstly, of course, objects must be "illuminated" in some way. For this purpose the radar antenna emits a kind of "light" in the form of high frequency *electromagnetic wave bundles (pulses),* which are reflected by the "targets" and picked up again by the antenna. The radar eye detects all objects whose electromagnetic data differ from those of their surroundings, but only in a *two-dimensional plane,* in the same way as we perceive objects with one eye. The component which would enable distance to be ascertained is thus missing. Radar solves this problem by measuring the *time* the wave bundles take to travel from the antenna to the object and back again. The relationship between this time t and the distance from the antenna to the target (ρ) is $\rho = 1/2\ t.c$, where c is the speed of light (300,000 km/sec) at which electromagnetic waves travel in space.

Objects which reflect electromagnetic waves are known in technical language as *passive secondary reflectors.* The reflecting surfaces can be "enlarged" by making them *active,* i.e., by installing in them an apparatus that amplifies the radar waves before returning them. For this purpose *repeaters* or *transponders* are used, and the whole system is known as *secondary radar.*

If the objects detected by radar eyes are moving towards the antenna (or away from it), the frequency of the reflected waves differs from that of the original waves. This phenomenon is based on the so-called *Doppler effect,* which also

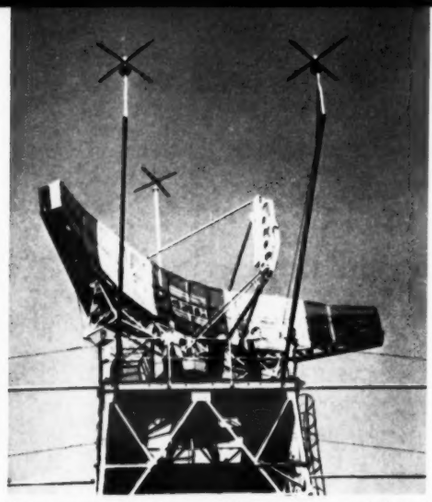
The antenna arrays at Société Française Radioélectrique's radar research and test centre (France).

Transmitter hut, antenna tower and surveillance radar antenna at Idlewild Airport, New York (General Electric Co. – U.S.A.).



Standard Telephones & Cables Precision Approach Radar (Britain). The vertical antenna scans up and down the approach sector, the horizontal antenna from side to side. On the roof, a directional antenna for transmitting the radar image to the control tower.

Above the search antenna of Cossor Radar's Mark 6 primary radar (Britain) is the secondary radar antenna for the reception of transponder signals.



This Thomson-Houston surveillance radar is installed at Paris-Orly Airport: range 95 miles.

applies to sound waves. Listen to a train whistling as it goes past; the note is higher as the train approaches, lower as it recedes. Radar equipment which makes use of this phenomenon is known as *Doppler radar*.

For general supervision of the air space use is made of *surveillance radar,* whose antenna rotates about a vertical axis and scans the air space. The longer the equipment's range, the more closely the electromagnetic waves transmitted by the antenna must be *grouped together*. In other words the "angle of sight" is reduced, as otherwise it is no longer possible to determine direction accurately. This is done by giving the antenna a special shape. In addition, the geometrical dimensions of the antenna reflector must be large in relation to the length of the radio waves used. These requirements are met, for example, by the radar equipment shown in the accompanying pictures. Makers are General Electric Co. and Raytheon Manufacturing Co. (U.S.A.), Thomson-Houston and Société Française Radioélectrique (France), Cossor Radar, Ltd. and Decca Radar Ltd. (Britain).

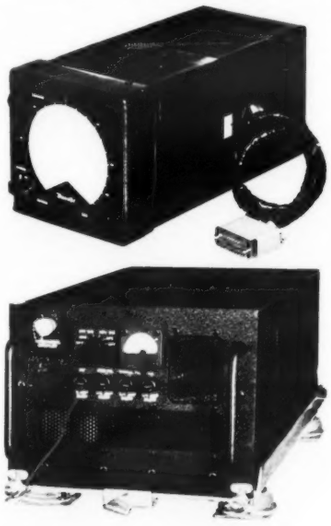
Precision Approach Radar is designed for a different purpose. It uses two antennae, which scan the approach sector beyond the runway, display the echoes of approaching aircraft on scopes and enable them to be "talked down" to a safe landing on instruments. One antenna scans the approach sector up and down, the other from left to right. Standard Telephones & Cables Ltd. (Britain) builds the PAR equipment illustrated here. Similar systems are also made by Bendix Aviation Corp. (U.S.A.), Thomson-Houston (France) and others.

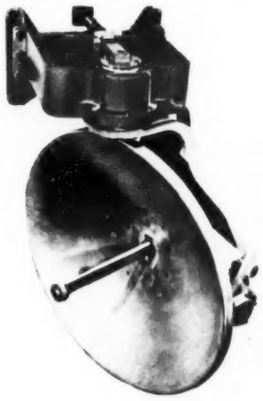
This surveillance radar antenna (MR 75) built by Decca Radar Ltd. (Britain) transmits and receives the electromagnetic waves which watch over the air space around Montreal.

Whereas all these radar installations are stationed on the ground, modern commercial and military aircraft are also equipped with *airborne radar*. Doppler radar, for instance, provides the pilot with very accurate navigation assistance, independent of ground stations. Such equipment is manufactured, for example, by Marconi's Wireless Telegraph Co., Ltd. (Britain) and General Precision Laboratory (U. S. A.).

More wide-spread in use than Doppler radar is *storm-warning radar,* which, fitted in the fuselage nose, scans the air space ahead of the aircraft for storm clouds. By means of this radar eye, the pilot sees storms miles ahead and can change course in time to avoid them. Ekco Electronics, Ltd. (Britain), Bendix Aviation Corp., Radio Corporation of America and Collins Radio Company (U.S.A.) have developed storm-warning radar.

Transmitter-receiver, scope and rotating antenna reflector for Bendix Aviation Corporation's airborne storm-warning radar (U.S.A.).





RCA storm-warning radar antenna in the nose of a Convair 340 (U.S.A.).

Buying-Time

The duel between modern engineering and the Arctic: main road at a supplies depot in the DEW line.

The U.S. and Canadian Radar Warning Chains

By Charles Corddry, Washington

The most extensive electronic warning system in existence today is in the north of the American continent.—The following is a personal account of a tour of the American radar chains by Special Correspondent Charles Corddry, of Washington. Editors.

The United States and Canada rapidly are raising a gigantic electronic umbrella over the North American Continent to provide security against surprise air attack.

Statesmen and military men believe that if *surprise* attack can be forestalled there is a good chance of avoiding any attack at all. Warning time derived from the Arctic and sub-Arctic alarm systems and their seaward extensions would enable U.S. long-range retaliatory forces to get into action before being destroyed on their bases. The northern warning lines thus take their place with the strategic air force itself as prime elements in the deterrent power of the west.

In another ten months the two lines, erected at a combined cost of more than $ 800,000,000 to give about three hours warning to major target areas, should be fully operating from end to end across the Continent.

Elements of the *Mid-Canada Line* lying west of Hudson Bay already are in operation. When completed, the line will represent an electric barrier stretched from the rocky coast of Labrador to the Pacific, generally along the 55th parallel of latitude 400 miles above the U.S. border and 500 to 700 miles north of principal industrial targets and Strategic Air Command bases in the northern United States. It will have cost some $ 200,000,000.

At the extreme top of the continent on the Arctic shore is the *Distant Early Warning (DEW)* Line, covering the area from the Fjord-marked east coast of Baffin Island to Alaska's Cape Lisburne which is within radar view of Russia. Like the Mid-Canada

Building a radar station in the DEW line, the most northerly radar warning chain, which stretches from Baffin Island, Northern Canada, to Cape Lisburne, Alaska. Its radar will reach out as far as Siberia.

Cold work for a bulldozer . . . Laying out an emergency airstrip before beginning construction of a DEW station.

Line, the one across the frigid northern wilderness runs 3,000 miles, and an extension is being added to cover the *Aleutian Island chain* in the Pacific. Some parts of DEW Line are expected to be in operation this Summer. When completed, the line, some 1,000 miles north of the Mid-Canada Line, will have cost more than $ 600,000,000, a construction project called by the U.S. Air Force "the biggest Arctic operation of all time".

Though they are quite dissimilar in construction and operation, the two alarm systems have these factors in common:

1. They are warning lines, not combat lines. The combat line, from which interceptors and other defense weapons can be controlled after warning is received from the north, is the Pinetree Chain along the U.S.-Canadian border. However, both northern alarm systems are built so that they can be converted into tactical lines should that be desired in the future. In view of Russian weapons advances, there already is serious study in Canada of moving air defense weapons north to the Mid-Canada Line in another five or six years.

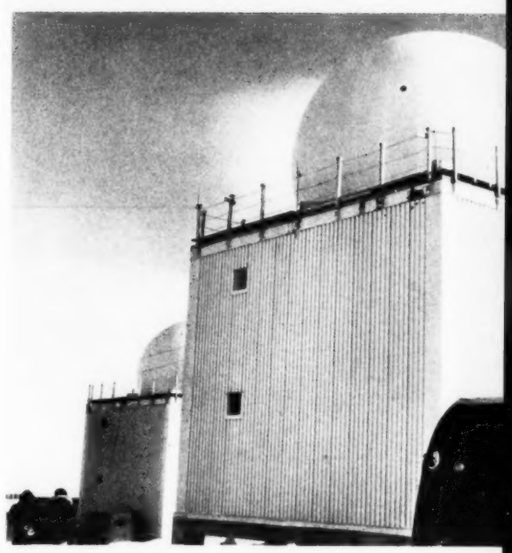
2. Construction of both lines has been accomplished in the face of incredible obstacles—terrain that ran the gamut from mushy flatlands to almost impassable mountains, sites that could be reached only by helicopter, winds up to 100 knots and temperatures down to 50 below zero (F.).

3. Both lines have the mission of giving the Strategic Air Command time to become airborne before its bases are attacked, alerting and positioning air defense forces, and giving the civil population some opportunity to prepare against impending attack.

4. Both were made possible by scientific developments which reversed earlier estimates of the vast manpower and money requirements and near impossibility of such warning systems. The DEW line may be manned by as few as 1,200 civilians, recruited and trained by Federal Electric Corporation, subsidiary of International Telephone and Telegraph. The Royal Canadian Air Force estimates that 800 civilians can man the Mid-Canada Line, many of whose stations will be entirely automatic after a six-month trial period.

*

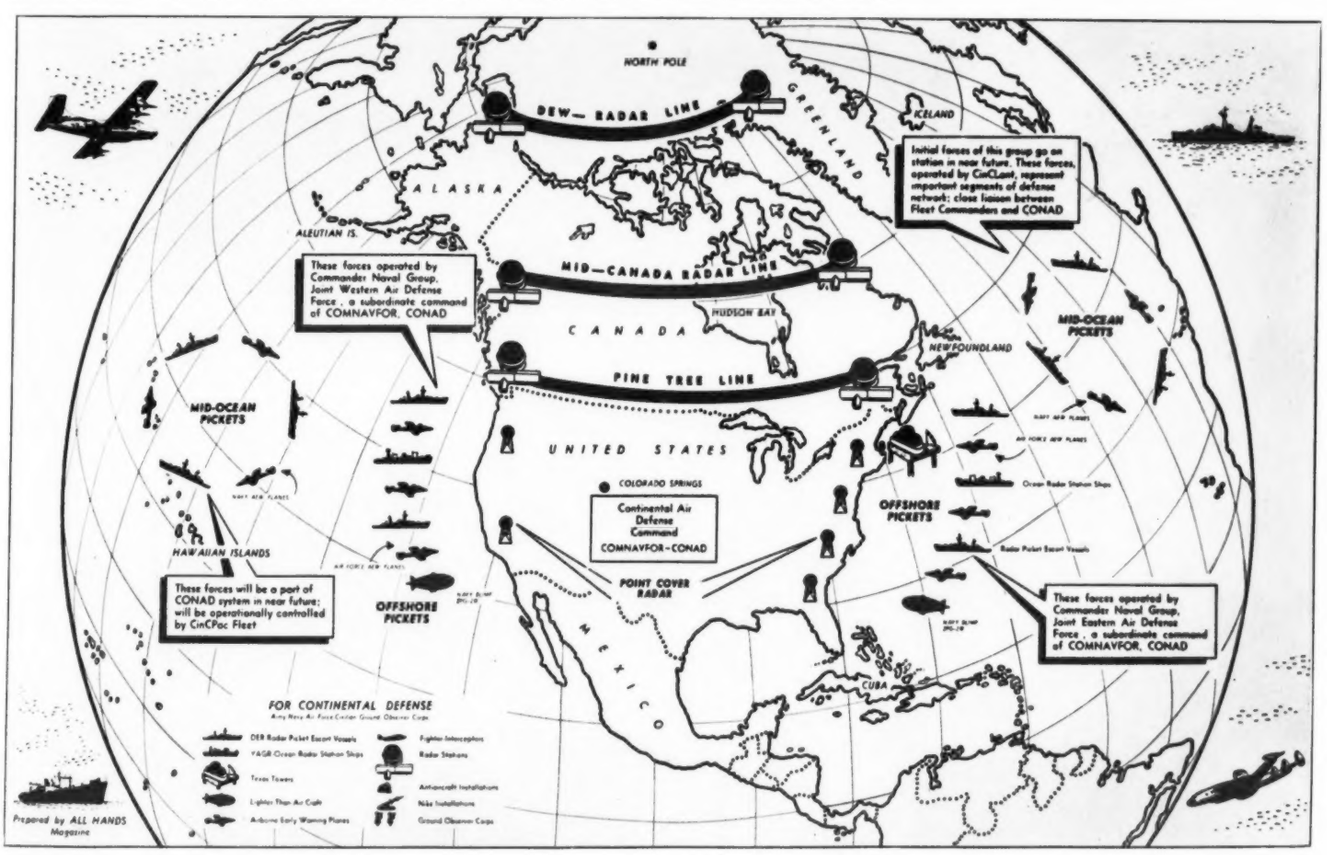
Touring both lines, by airplane, helicopter, truck and snowmobile, in good weather and bad, over mountains, tundra and frozen lakes, one gathers a wealth of impressions and, within security limits, official information as to the lines' military usefulness and limitations.



DEW line radar towers on Baffin Island.

The DEW Line, being installed by Western Electric Company and a group of subcontractors, consists of a string of rotating radars providing overlapping coverage, with gap-filler radars covering the blind spots down to perhaps 1,500-foot altitude. Like all radar, that on the DEW Line can be jammed but all possible anti-jamming techniques are being employed. Jamming, in

Eyes and ears to warn a continent: The three U.S.-Canadian radar chains – Distant Early Warning line, Mid-Canada Line and Pine Tree Chain – form only part, though an extremely important part, of the two countries' warning and defence facilities. CONAD (Continental Air Defense Command) also has numberless radar stations on the continent, as well as radar picket ships and aircraft operating in the Pacific and Atlantic to extend the warning chains in the Far North.


NORTH POLE
DEW – RADAR LINE
GREENLAND
ICELAND
ALASKA
ALEUTIAN IS.
Initial forces of this group go on station in near future. These forces, operated by CinCLant, represent important segments of defense network; close liaison between Fleet Commanders and CONAD
These forces operated by Commander Naval Group, Joint Western Air Defense Force, a subordinate command of COMNAVFOR, CONAD
MID-CANADA RADAR LINE
CANADA
HUDSON BAY
NEWFOUNDLAND
MID-OCEAN PICKETS
PINE TREE LINE
MID-OCEAN PICKETS
UNITED STATES
COLORADO SPRINGS
Continental Air Defense Command COMNAVFOR-CONAD
OFFSHORE PICKETS
HAWAIIAN ISLANDS
These forces will be a part of CONAD system in near future; will be operationally controlled by CinCPac Fleet
OFFSHORE PICKETS
POINT COVER RADAR
These forces operated by Commander Naval Group, Joint Eastern Air Defense Force, a subordinate command of COMNAVFOR, CONAD
MEXICO
CUBA
FOR CONTINENTAL DEFENSE
Prepared by ALL HANDS Magazine

any event, is in itself good warning of attack. The line should provide about three hours warning of a transpolar approach and is designed to alert the entire continental defense establishment. Bombers penetrating the DEW Line could be "lost" to trackers for perhaps an hour before arriving over the Mid-Canada Line. But fuel limitations may be expected to hold attackers to reasonably predictable courses. Navigation aids, ice and gravel runways, maintenance and repair hangars make the DEW Line outposts potential sites for air defense weapons if it should be decided to convert the line from an alarm to a tactical system.

The Mid-Canada Line, built by Trans-Canada Telephone System and its subcontractors, is essentially an electronic "fence", distinguished by a continent-wide string of steel towers rising to heights of 350 feet with dish-shaped antennas on top. It has no rotating radar and cannot track and pinpoint enemy positions. Its equipment, designed at McGill University, Montreal, is intended to "confirm" an attack of which warning has been received from the DEW Line. The electronic towers send signals when the line is breached, to machines in which automatic pen recorders trace data on paper tapes.

The audible signal received on DEW Line radar and the automatic recordings on the Mid-Canada Line drastically reduce previous estimates of necessary manpower. A relatively small number of military men at key control stations along the lines can study data received from the alarm circuits and flash appropriate warnings to air defense headquarters in the United States and Canada.

The U.S. Navy icebreaker *Eastwind* cutting a path through the ice flows in Baffin Bay for two DEW line supply ships. – The two mysterious objects in the foreground are helicopters parked on the icebreaker's landing platform.

One of the chief criticisms directed at the warning lines is that they are designed against bomber attacks and thus may become obsolete rather quickly as intercontinental ballistic missiles are developed. The criticism is rejected by airmen of both nations.

The R.C.A.F., in fact, has stated unequivocally that when the day of missiles arrives forward defense lines will be vital and the two now nearing completion "will merely require to be modernized".

Air Vice Marshal C. R. Dunlap, Canadian Vice Chief of Air Staff, told the first correspondents touring the Mid-Canada Line that Russia could be expected to use the jet bombers now being introduced into their forces until the late 1960's. Even with the arrival of the intercontinental ballistic missile "toward the end of the 1960 period" this Continent may be faced with a continuing threat of bomber attack. He looked for the two weapons to complement each other, saying it was hard to imagine I.C.B.M.'s being able to strike targets with the precision of bombers.

*

Construction of the two early warning lines is a new saga of men against the elements, and it could not have been written—this story of defense against the airplane—without hundreds of commercial and military transport airplanes and helicopters.

Rough estimates indicate that about 600,000 tons of material have been moved into the two lines, and probably as much as a quarter of the total was air-lifted.

Desolate, unknown areas had first to be mapped by air, then siting teams went in by ski-plane to open camps and clear air strips. Sometimes the strips were cleared with seven-ton tractors dropped by parachute. On the DEW Line, Douglas *Globemasters* weighing 168,000 pounds landed on ice strips, frozen to six-foot depths, and disgorged the heavy equipment that could not be brought in in any other manner. On the Mid-Canada Line, World War II Consolidated PBY amphibians, modified with skis, carried supplies to lakes, frozen or thawed, and from such depots helicopters had to lift the materials to many of the hilltop sites. In the eastern portion of the Mid-Canada Line, where everything moves by air because of the impassable terrain, 'copters carried 10,000 tons of material and 14,000 passengers last year.

Military men have no illusion that they are erecting an impregnable defense in the high North. But they do not regard these new "wonders of the world" as "Maginot Lines"either.

"Alert time is more important than anything else", Gen. Curtis E. LeMay, Strategic Air Commander, told a U.S. Senate Committee investigating the status of American air power last year. "That is the factor that will give us ability to save more of the force."

And that is the factor the warning lines in the arctic and subarctic are designed to provide.

No one doubts Soviet Defense Minister Georgi Zhukov's recent claim that the Red Air Force can "deal crushing blows". But many doubt it would try to deal blows with the Kremlin aware that there would be enough warning time to bring down the retaliatory forces on Russia.

"This story of defense against the airplane could not have been written without hundreds of commercial and military transport airplanes and helicopters." A Fairchild C-119 *Flying Boxcar* (left) and two Grumman SA-16 amphibians of the air-sea rescue service (right) being prepared at a supply depot for a flight to the DEW line outposts.

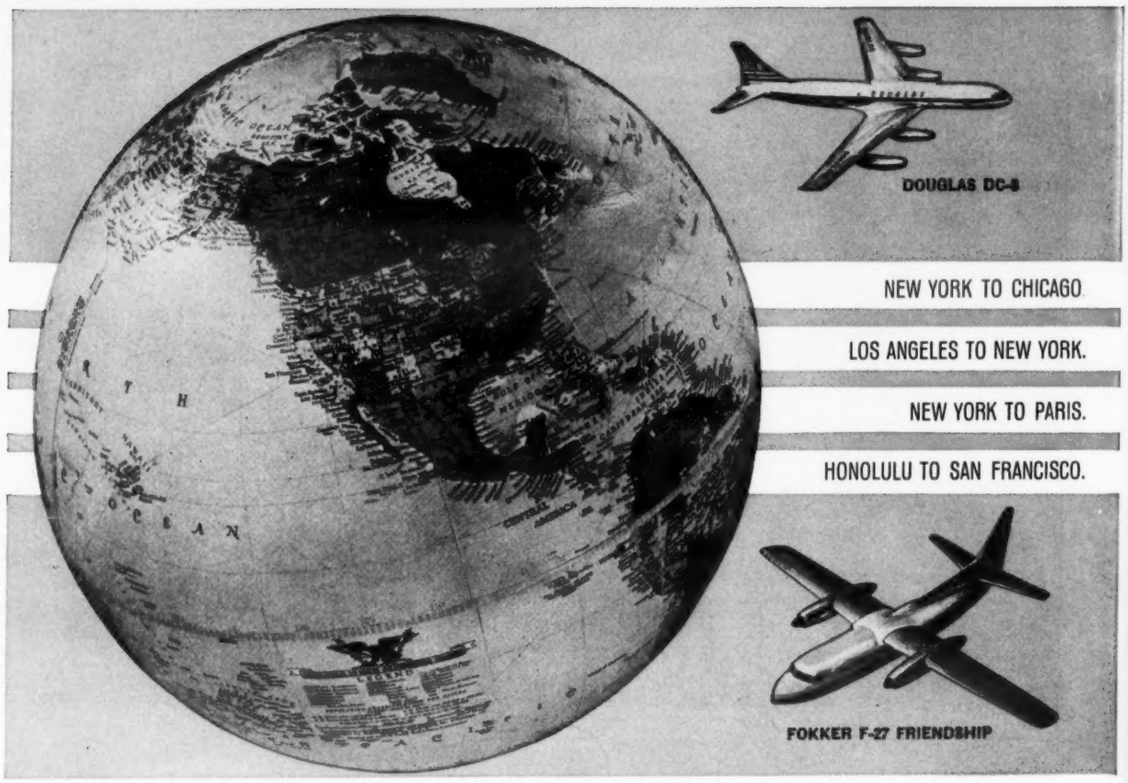
"...glad to know Decca's aboard..."

"Filthy weather!"..."Yes, isn't it!"..."*Amazing how these chaps find their way around in weather like this.*"... "It is indeed—but they've got a little black box up in the sharp end—shows the pilot exactly where he is, in fog, gales and anything else our climate cooks up for us." "*You mean the Decca Navigator?*" "That's right—astonishing system—they say it's the only one that will cope with the colossal growth of air traffic. I shall feel a lot safer when I know that all aircraft, including these new jets, are flying to the same plan and everyone knows exactly where they are." "*I'm with you—cuts a lot of the worries out of flying—much better time-keeping I've noticed in planes using Decca—and a jolly sight safer too—no bumping into mountains—and when* every *plane fits it, there'll be far less risk of these collisions one reads about.*"

THE DECCA NAVIGATOR

THE WORLD'S MOST ACCURATE NAVIGATION SYSTEM

THE DECCA NAVIGATOR COMPANY LTD LONDON



Jet airliners shrink globe . . .

When you and your family board these new jet airliners, you'll be stepping into a completely new era of transportation designed to get you where you are going faster, more comfortably and more dependably. To appreciate the progress that has been made, following are some exclusive jet problems that had to be licked and some original answers to those problems worked out by Bendix Aviation Corporation.

For example, the starting, generating and ignition systems used on reciprocating engines were not applicable on jets. One of our new Bendix jet starters, small enough to put in a breadbox, produces 450 h.p. to crank a giant jet engine 1800 r.p.m. in three and a half seconds.

Igniting a jet is like lighting a match in a tornado. An ordinary spark has no chance. New Bendix jet ignition produces a super spark that fires jet engines immediately.

Jets are fuel hogs with very sensitive digestive systems. Not too much, not too little—the mixture's got to be just right. Speed, temperature and altitude affect this mixture. Thus, fuel-air proportions must be changed rapidly and automatically. New Bendix* fuel-metering and engine control systems are precise and automatic, take another tough problem off the crew's backs.

Jet speeds necessitate more accurate navigation and piloting. Here several exclusive Bendix devices team up for greater precision: The

ADVANTAGES OF THE JET AGE WILL BE JET PROBLEMS—HAS

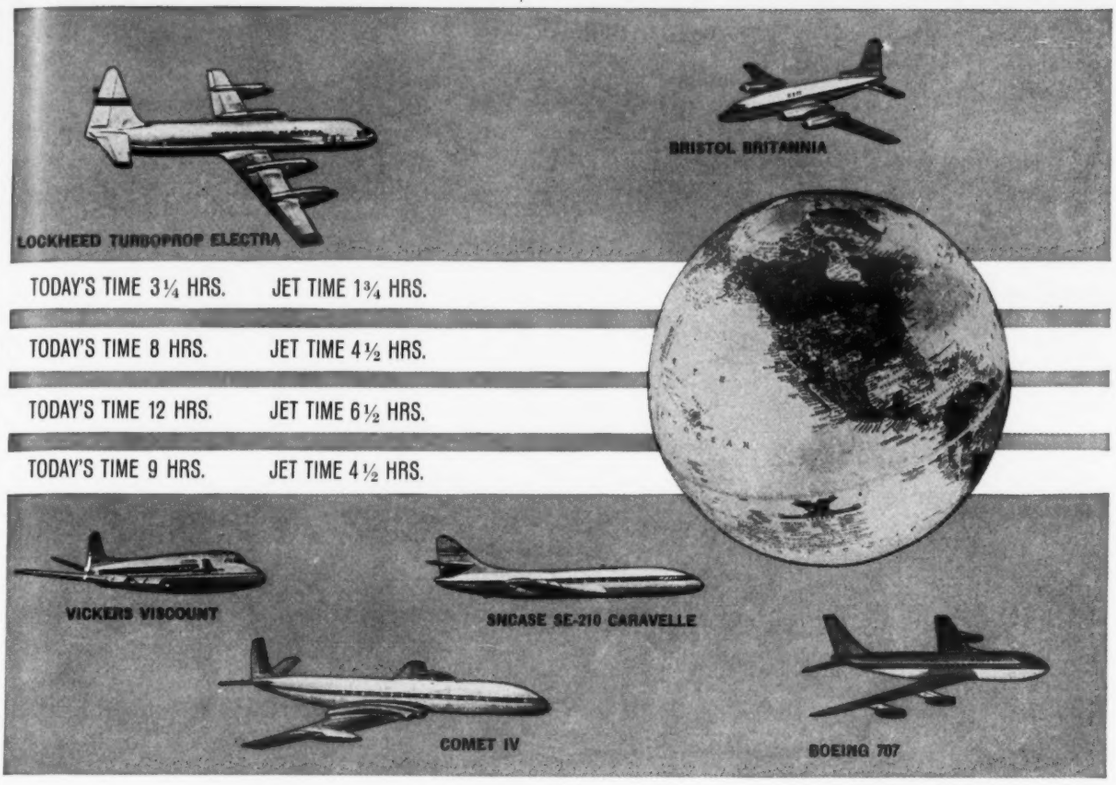
COMPLETE TRANSISTORIZED NAVIGATION AND CONTROL SYSTEM
Includes automatic pilot capable of automatic landing approaches; Flight Director systems; heading reference systems.

AIRBORNE RADAR SYSTEM
Sees storms 150 miles away and shows how to avoid them for smoother ride.

RADIO COMMUNICATION SYSTEM
Including receivers, transmitters, flush antennae, radio compass, radio magnetic indicators, marker receivers, glide slope receivers, VOR-localizer receivers, Omni-mag indicators, cockpit loud speaker, distance measuring equipment, transponder beacon and selective calling, passenger address and transistorized interphone systems.

LIQUID OXYGEN SYSTEM
Automatic high-altitude oxygen system for passengers plus flight crew oxygen system.

SPECIAL INSTRUMENTS
To measure Mach airspeed and fuel flow; accelerometers; specially lighted turn-and-bank and rate-of-climb indicators.


LOCKHEED TURBOPROP ELECTRA
BRISTOL BRITANNIA
TODAY'S TIME 3¼ HRS. JET TIME 1¾ HRS.
TODAY'S TIME 8 HRS. JET TIME 4½ HRS.
TODAY'S TIME 12 HRS. JET TIME 6½ HRS.
TODAY'S TIME 9 HRS. JET TIME 4½ HRS.
VICKERS VISCOUNT
SNCASE SE-210 CARAVELLE
COMET IV
BOEING 707

will cut travel time in half!

YOURS SOONER BECAUSE BENDIX ANTICIPATED THESE DEVICES READY NOW

COMPLETE LANDING GEAR
Including wheels, brakes, shock absorbers and "Cerametalix" brake lining—our special friction material developed for stopping jets.

TURBINE STARTERS
Originated by Bendix to solve the problem of starting jet engines.

AC GENERATING SYSTEM
Including fault-detecting and regulating devices and inverters.

RELIABLE, RUGGEDIZED ELECTRON TUBES

JET IGNITION SYSTEM
Provides extra hot spark for starting and high altitudes.

FUEL-METERING AND ENGINE CONTROL SYSTEM
Provides proper air-fuel mixture at all speeds, temperatures and altitudes.

HYDRAULIC CONTROLS
For raising and lowering landing gear, applying boost power to control surfaces. Includes servo-valves, accumulators, positioning actuators, pressure reducers, relief valves, hand pumps, flow dividers and cylinders.

Polar Path* compass, which made polar navigation practical and which is equally accurate anywhere; the Flight Director, a simplified navigation system in which two instruments replace many; and the first completely transistorized automatic pilot which will not only fly jets with more exactness than human pilots but automatically bring them in for pinpoint landing approaches.

Ordinary brakes and lining can't stop the fast, heavier jets. New Bendix* jet airplane brakes and our special Cerametalix* friction material licked the stopping problem. New Bendix* landing gear and shock absorbers set them down softly.

Airborne radar to spot storms ahead, surveillance radar to help control airport traffic, G. C. A. radar for bad weather landings, a complete line of ground and air radio communications systems and automatic liquid oxygen systems are some of the other proven devices we have ready now for passenger jets.

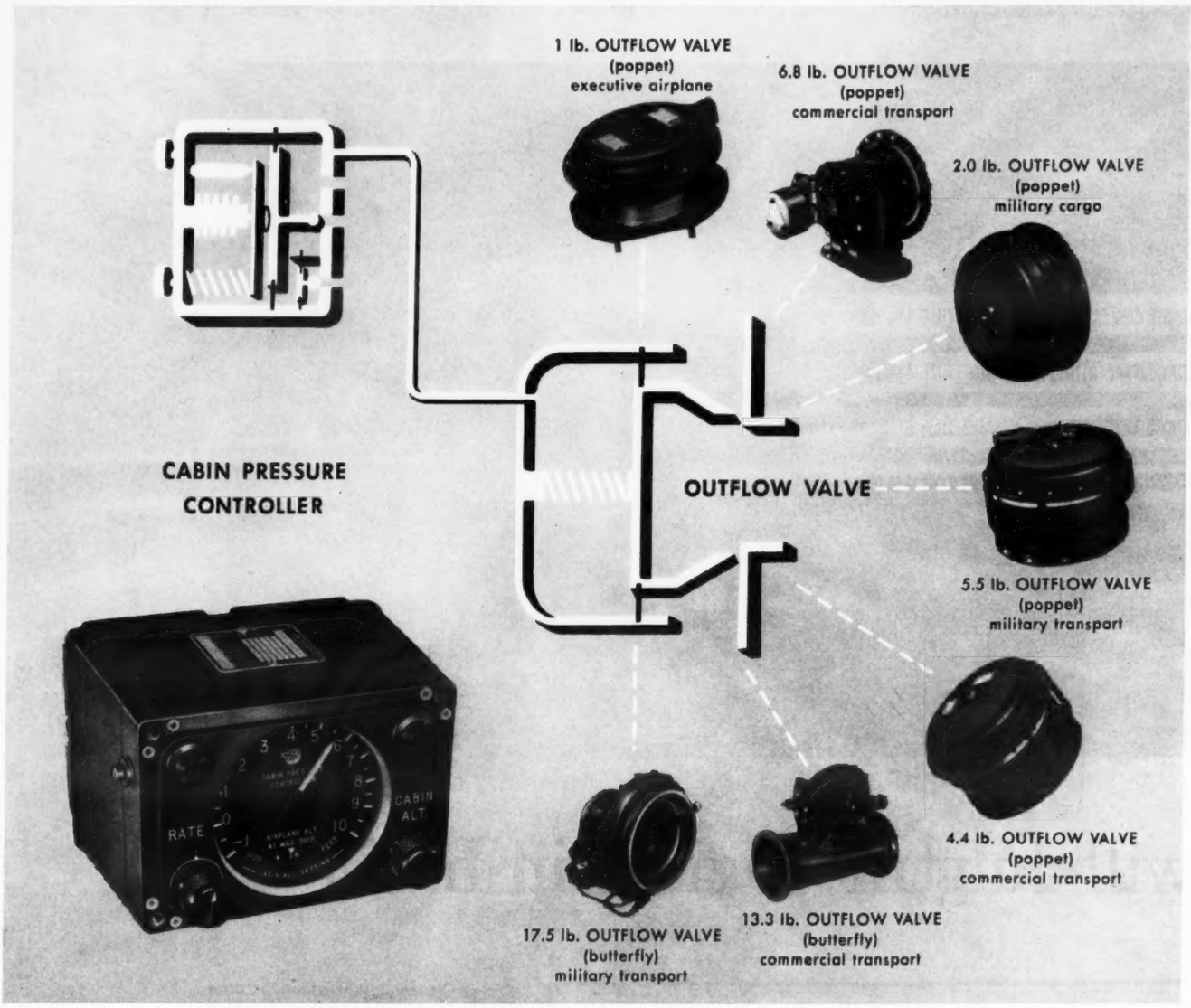
This is probably the most complete package of equipment ever offered a new industry by one supplier.

Bendix has hundreds of products for other fields, also. Write for "Bendix and Your Business".

**Trademarks of Bendix Aviation Corporation*

Bendix International

Division of Bendix Aviation Corporation
205 East 42nd Street, New York 17, N.Y., U.S.A.
Cable "Bendixint" N. Y.



Two unit pressure control

FOR ALL SIZES OF AIRCRAFT CABINS

Simple, proved AiResearch pneumatic system operates independently... requires no outside power

The two elements of the complete AiResearch cabin pressure control system are a pneumatic controller and an associated outflow valve.

Only calibration is required to adapt the controller to various aircraft cabin pressure requirements. Minimum or no servicing is needed. The outflow valve is a simple diaphragm and spring operated valve connected to the controller by a pneumatic line. It may also serve as a safety valve in emergencies.

An electrical or pneumatic override can be provided for manual control.

This system is immediately available for all aircraft models.

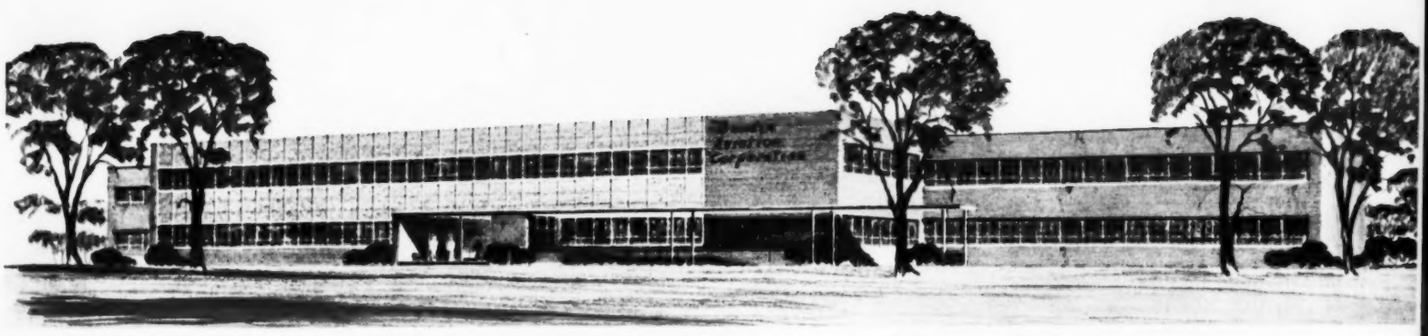
You are invited to write for specific information on our systems and components and for the addresses of our licensees and representatives in Europe, the United Kingdom and Japan.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California · Phoenix, Arizona · U.S.A.

Designers and manufacturers of aircraft and missile systems and components: REFRIGERATION SYSTEMS • PNEUMATIC VALVES AND CONTROLS • TEMPERATURE CONTROLS
CABIN AIR COMPRESSORS • TURBINE MOTORS • GAS TURBINE ENGINES • CABIN PRESSURE CONTROLS • HEAT TRANSFER EQUIPMENT • ELECTRO-MECHANICAL EQUIPMENT • ELECTRONIC COMPUTERS AND CONTROLS



The whole of Bendix research activities is to be concentrated in this projected building in Detroit.

False start makes a winner: Bendix Aviation Corporation

The Bendix annual reports for 1938 and 1956 are as different as day and night. At the beginning of 1957, President Malcolm P. Ferguson submitted a victory bulletin to shareholders which contained few passages likely to cause concern: "I do not recall any peacetime year when the leadership and vision of the Corporation's engineering and the capability of its sales forces were more forcefully demonstrated."

Twenty years earlier, on the other hand, Vincent Bendix, the company's President at that time, published an annual report in which the bitter truth was only flimsily veiled: "Your Corporation, as a result of the reorganization moves, is now an operating company with a more simplified corporate organization. Greater economy and efficiency is resulting with better coordination of engineering, manufacturing and distribution."

The position could have been formulated even more concisely: the firm was heading for bankruptcy... Since the company's foundation in 1929, a little too much had been expected of it by its extremely active creator, Vincent Bendix. He was one of those dynamic personalities who consider a day lost if they do not launch into something new. A creative urge which—if employed in wise doses—can lead to prosperity and healthy diversity, as borne out by the subsequent history of the Bendix concern. But under the conditions prevailing at that time, every additional obligation represented a considerable burden, since the development of the firm was overshadowed by the crippling economic crisis of the 'thirties. Nevertheless, eventually Vincent Bendix, whose interests ranged from bicycle, automobile and aircraft equipment to watches and washing machines*, got involved in land speculations—not at the company's expense, but at his own risk—and on June 9th, 1939 he was declared insolvent.

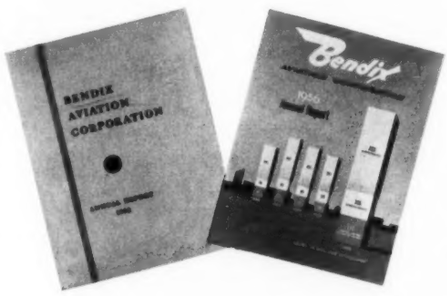
As regards Bendix Aviation Corporation, the majority shareholder, General Motors, at once stepped forward and announced that the firm was in no way affected by its founder's difficulties. Since even during a slump the word of General Motors is accepted, the Bendix enterprises emerged unscathed from the affair and embarked on a future which was to bring world renown to the name of Bendix.

Naturally, General Motors imposed a condition for repairing the damage—the reorganization of the Board. To all intents and purposes, leadership of the company was already at that time transferred into new hands, although Vincent Bendix did not formally resign as President until 1942. Exposed to heavy criticism of a political and economic nature, Bendix, after leaving the company, turned to helicopter construction. He died in 1945 at the age of 62. In the turmoil of the closing stages of the war, the news of his death was hardly noticed, and it was some time before it reached Europe.

It would not be just to Bendix to remember him only by the company's name and "blot out" his name in the chronicle of aviation.

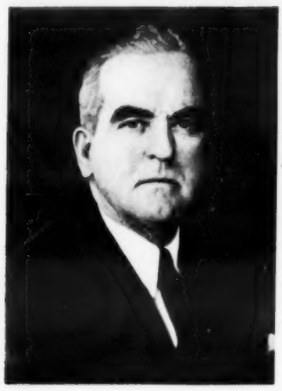
The embarassing annual report for 1938 contained a very positive piece of information, despite all the bad news—the decline in sales from 40.6 to 30.8 million dollars; the decision to pay no dividends and to stop payments of bonuses to personnel. With remarkable foresight Vincent Bendix at this early stage already anticipated future development trends. Under the heading "Bendix Aviation Radio Equipment" the new ILS procedure and the Bendix ILS devices were described and illustrated. "Functioning through radio beam reception, it provides visual guidance to the pilot... leading the airplane to a proper landing under 'Zero-Zero' flying conditions." The year was 1938... Despite everything, Vincent Bendix had paved the way which led Bendix Aviation Corporation to fame.

* It should, however, be pointed out that Bendix Aviation Corp. has nothing to do whatsoever with the washing machines known under this name. Although Vincent Bendix in 1935 acquired patent rights for the machines, he never manufactured them. In 1940 he disposed of the patents, including the right to the use of his name.



Malcolm P. Ferguson, President of Bendix Aviation Corporation.

Charles Marcus, Vice-President of Bendix Aviation Corporation.



Theodore Voorhees, Assistant General Manager, Bendix International Division.

Henry A. Correa, Sales Manager, Bendix International Division.

What of the new team, under whose direction peacetime sales have since risen from 30 million dollars to 544 million dollars?

Malcolm P. Ferguson, who has been with the company since its foundation, and later was in charge of Eclipse Machine Co., Elmira, a Bendix subsidiary, moved up to become President of Bendix in 1946. He is an engineer, but also a good businessman. He knows that the American aircraft industry's sore point is its excessive dependence on Government contracts. Working tirelessly, he succeeded in raising the proportion of Bendix' civilian orders to over 30 percent of total sales. In establishing *Bendix International Division,* New York, he created an export organization which saw to it that there should be hardly an aircraft or airport anywhere in the world which did not use some Bendix equipment somewhere. But he has by no means forgotten that, in addition to organic growth and disciplined routine work, it is willingness to embark on new ventures which is responsible for the company's dynamic advance. With the *Kansas City Division,* Bendix entered the field of atomic research and industry. The Division became a prime contractor of the United States Atomic Energy Commission.

A full appreciation of Ferguson's entire staff of assistants would be beyond the scope of this short review. A few notes will have to suffice.

The mainspring of the company's tireless expansion on markets throughout the world is perhaps *Charles Marcus,* Bendix Aviation's Vice President, a man past middle age but still extremely active and go-ahead.

Theodore Voorhees, who was appointed General Manager of Bendix International Division in 1948, bears equally great responsibility for overseas sales.

Among the younger generation, mention should be made of a "globe trotter" who never misses an air show at Paris or Farnborough and who is persona grata in all capitals: always smiling, fluent in a number of languages, which he speaks without accent, *H. A. Correa* is the right hand of Charles Marcus and Voorhees.

*

Much more could be said, but let figures speak for themselves. They describe the rise and world standing of this leading accessories producer more eloquently than lengthy tirades.

The Bendix concern today consists of 24 divisions located in different parts of the United States, as well as 12 subsidiaries and associated companies in America and elsewhere. The concern's manufacturing programme covers a range of over 350 production categories.

In 1938, Bendix Aviation Corp. employed 7,752 people with a total annual payroll of $12,000,000. In 1956 Bendix provided work for over 47,000 men and women, and the payroll reached more than $112,000,000.

Results for 1956 show that these workers are worth their pay: Sales increased from $567,000,000 in 1955 to $581,000,000; the order backlog went up from $480,000,000 (September 30th, 1955) to $544,000,000 (September 30th, 1956), and, according to a New York financial report published early in May 1957, reached a value of $580,000,000 on March 1st. Although net earnings dropped slightly—from $25,800,000 to $24,200,000, this was not due to any slackening of the company's efforts. On the contrary: in addition to the rise in prices and wages, which affects the whole of the American industry, large scale investments on which the future of Bendix depends are chiefly responsible for the decline in profits. The value of plant, buildings and equipment increased from $49,400,000 to $58,600,000, while net working capital went up from $111,000,000 to $112,000,000. A cash dividend of $2.40 per share ($2.00 the previous year) as well as a 5 percent stock dividend were paid.

In June 1956, "Fortune", the leading U.S. economic review, published an appreciation of the organization, commending its enterprise and shrewdness. Today, a year later, the assessment still stands. *EEH*

Bendix Radio Division, Baltimore, Md., manufacturers of communications and electronic equipment.

Inertial Navigation

Position finding by accelerometers, gyroscopes and pendulum

By Norman F. Parker and Charles P. Greening, Autonetics Division,
North American Aviation Inc., Downey, California

The first flyer to navigate by inertial guidance was certainly not a parrot. Otherwise the historic flight which a Boeing B-29 *Superfortress* made from Bedford, Massachusetts, to Los Angeles, California, in February 1953, using only inertial sensing elements, integrators and servo motors, would surely have attracted public attention long ago. In reality, however, it was not until mid-April, 1957 that Dr. Charles S. Draper, of the Department of Aeronautical Engineering, Massachusetts Institute of Technology, who was in charge of the experiment, revealed some details of the transcontinental flight. He disclosed that the aircraft, after 13 hours in the air and having covered a distance of roughly 2,200 nautical miles on a great circle course, had arrived within ten miles of Los Angeles International Airport entirely without intervention by the pilot, that the inertial navigation equipment then carried weighed no less than 2,700 lbs. and that the pilot, who had been taken along as a safety precaution, had never found a flight so boring. It looked as if he would soon be looking for another job, he said afterwards.

Since then, weight and size of inertial navigation equipment have been greatly reduced without, of course, decreasing their accuracy. The system is scheduled to be used in the United States' three I.R.B.M. weapons now under development *(Jupiter, Thor* and *Polaris)* and in the two I.C.B.M.s *(Atlas* and *Titan).* In addition, it appears to be capable of greatly simplifying navigation for high-speed civil aircraft, in particular the coming jet transports. At any rate, a number of American universities and aircraft manufacturers, including M.I.T., North American Aviation, Bendix Aviation Corporation and Lear Inc., as well as the U.S. Air Force Air Research and Development Command, are working on inertial navigation.

In the following article two leading scientists from North American Aviation Inc. write on the principles of inertial navigation in readily understandable terms. The first of the two authors, who is Assistant Chief Engineer of the Autonetics Division, read a widely acclaimed paper on the same subject to the last AGARD seminar on "Guidance and Control" in Venice. Editors.

The basic principles of inertial navigation have been known for many years. In fact, the physical laws were formulated in the time of Galileo and Newton and some of the more subtle effects were recognized by Jean Foucault, Max Schuler and others. However, only recently, with the advent of high-speed aircraft, have the shortcomings of conventional navigation schemes become sufficiently important to justify the intense development effort required to make inertial navigation practical.

Dead reckoning techniques, based on airspeed measurements and compass direction information, are marginal as to accuracy. This is particularly true at high altitudes where jet streams may be encountered, near the earth's poles where magnetic compass accuracy is poor, and in flights in which considerable distance must be traveled between known landmarks or other checkpoints.

Radio and radar navigation techniques are very well suited for many applications, especially for guidance near the origin and destination of the flight. They depend on the receipt of signals from the ground and, hence, are of limited use in military applications. They are also of restricted use over large oceans and are affected by magnetic storms.

Celestial navigation, based on measurements of the angular positions of stars relative to the local gravitational vertical, is adequate for navigation of ships and low-speed aircraft. However, as aircraft speed increases, this method becomes unreliable due to the inaccuracy involved in establishing the local vertical. The direction of the local vertical cannot be determined accurately by conventional techniques because accelerations of the vehicle cannot be distinguished from the accelerations due to gravity. An indication of the magnitude of error involved is given by the following example: Consider an aircraft on a course which a pilot considers to be straight but which is actually curved with a radius of curvature of 1,000 nautical miles (1,850 kilometers). At Mach 1, the centrifugal force associated with this very slight curve would introduce an error of approximately 18 nautical miles (33 kilometers).

Inertial navigation, on the other hand, is ideally suited for high-speed flight. The signal to be measured, namely acceleration, is large and the effect of the time build-up of error which occurs in inertial systems is reduced by the short flight times associated with high-speed aircraft. Although inertial navigation is also well suited for many applications in low-speed vehicles, it was the severe navigational requirements associated with high-speed flight that provided the impetus necessary to bring inertial navigation to its present state of development.

Physical Basis of Inertial Navigation

Inertial navigation as used in this paper means navigation with respect to space. It is accomplished by mechanization of Newton's second law of motion which states that force is equal to the time rate of change of momentum. While position and uniform velocity are not directly detectable without reference to external information, it is apparent from a consideration of Newton's second law that acceleration is directly detectable.

If a mass is suspended *(Fig. 1)* in such a way that it will be deflected from a neutral position by any force acting upon it, and so that a restoring force arises in the presence of the deflection, this force or deflection can be used as a measure of acceleration with respect to space.

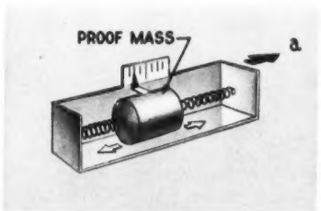


Fig. 1: Simple accelerometer with proof mass and spiral spring to measure acceleration in a single direction, along the "sensitive axis". The distance travelled by the mass is proportional to acceleration *a*.

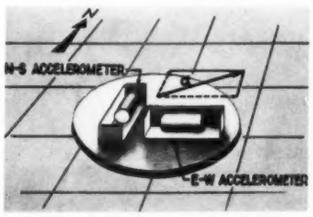


Fig. 2: With the aid of two single-axis accelerometers placed at right angles to one another, any acceleration in the plane defined by the two axes can be measured regardless of its direction.

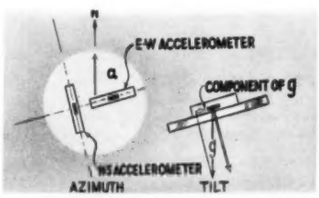


Fig. 3: Inaccurate azimuth setting *(left)* of the platform carrying the instrument or tilting *(right)* leads to errors.

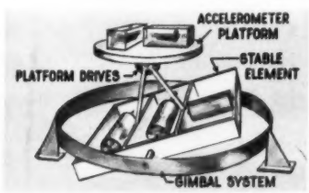


Fig. 4: The accelerometer platform is mounted in a gimbal system and stabilized by gyroscopes.

Fig. 5: If a torque moment is exerted on the stabilized axis of a gyroscope, the latter resists and precesses about its free axis, which forms a right angle with the stabilized axis and with the axis of rotation.

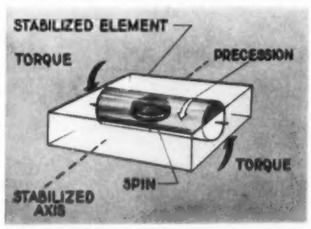


Fig. 6: During a flight parallel to the earth's surface the stable platform tilts in relation to the earth.

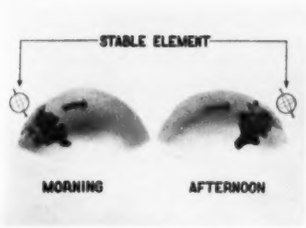


Fig. 7: A stable system on the earth's surface (e. g. in a parked aircraft) changes its position owing to the earth's rotation.

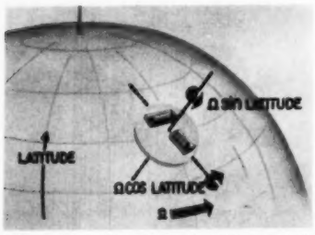


Fig. 8: An earth stabilized platform participates in the earth's rotation, by the cosine of its geographical latitude about its north-south axis, by its sine about the azimuth axis.

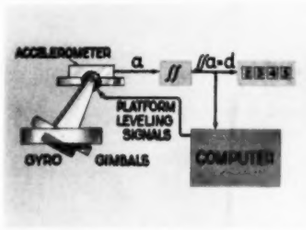
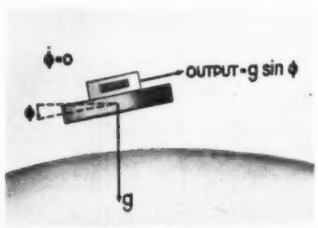
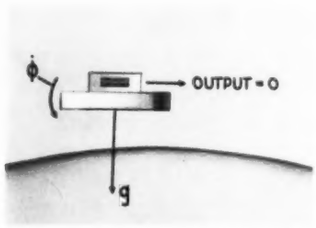


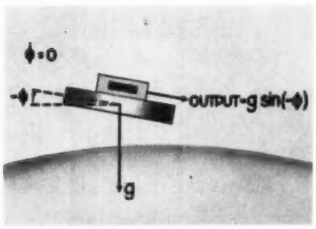
Fig. 9: Block diagram of a single-axis inertial navigation system.



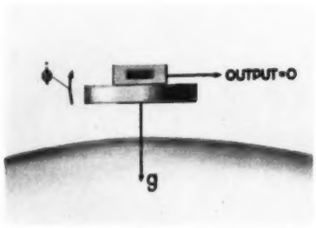
Figs. 10–13: A stationary platform in a parked aircraft started with an initial tilt of Φ rotates, under the 84-minute system (Schuler pendulum), . . .



. . . into the horizontal position after 21 minutes. The movement continues, and after another 21 minutes . . .



.. the platform reaches a tilt of *minus* Φ, whereupon the process is repeated in the opposite direction. Thus the platform...



. . . is back in the horizontal position after a further 21 minutes. It continues to oscillate in this way between *plus* Φ and *minus* Φ.

Fig. 14: Acceleration, velocity, distance and platform angle errors in the 84-minute system plotted against time, the whole based on an initial platform tilt.

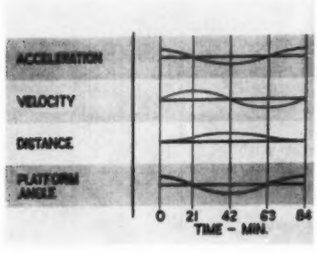
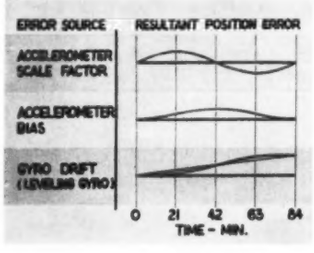


Fig. 15: Position error plotted against time for other sources of error, such as acceleration scale factor, accelerometer bias and gyro drift.



If the initial position and velocity of the accelerometer are known, position and velocity at any later time can be computed by detecting all accelerations and integrating with respect to time—once to obtain velocity and twice to obtain position.

Mechanization

The simple accelerometer *(Fig. 1)* is so arranged that it is sensitive only to accelerations along one axis, called the sensitive axis of the instrument. If two such accelerometers are mounted with their sensitive axes at right angles to each other *(Fig. 2)*, they can be used to measure any arbitrary acceleration in the plane defined by the two axes. If we consider an acceleration as indicated by the heavy arrow in a direction somewhat east of north, the north-south accelerometer will detect one component of the acceleration and the east-west accelerometer the orthogonal component. These acceleration components can be integrated separately and interpreted as distances north or south and east or west of the assumed starting point.

It is apparent that there is a need for stability of accelerometer orientation about all axes. If the platform upon which the accelerometers are mounted is misaligned in azimuth, as indicated *(Fig. 3)*, an acceleration in the northerly direction which should produce a reading only on the north-south accelerometer will also be detected to a slight degree by the east-west accelerometer. The integrated output in this case will be slightly in error in both directions since the true northerly distance will be slightly greater than that indicated, and the true east-west distance will actually be zero, although a value will be indicated.

It is also necessary to prevent the accelerometer platform from tilting about a horizontal axis *(Fig. 3)* because there is no way for any acceleration sensing device to distinguish between the acceleration due to gravity and an acceleration due to change in velocity.

The accelerometer platform can be stabilized, even in a moving vehicle, by mounting the platform in a gimbal system and providing gyroscopes which have the property of maintaining a fixed direction in space *(Fig. 4)*. One possible arrangement involves the use of three separate gyroscopes, each of which has a single axis of free motion perpendicular to its spin axis. Each gyro will then provide stability about an axis perpendicular to the free axis and the spin axis *(Fig. 5)*. A torque acting about a stabilized axis will be opposed by the gyro, which will precess about its free axis. The angle of precession can be used as a signal to counteract the torque by energizing servomotors in the stable element gimbal system.

If we expand the picture to include the effects of curvature of the earth and rotation of the earth, we find that corrections will have to be made to the platform orientation. Let us first consider the effects of motion over the surface of a spherical earth *(Fig. 6)*. Because the stabilizing gyros maintain their direction in a space coordinate system, motion of the system over the surface of the earth will result in an apparent tilt of the platform relative to the earth.

Even though the system may be stationary on the surface of the earth, it will develop an apparent misorientation after a short time of operation due to the rotation of the earth. That is, the platform will appear to rotate from east to west (like the stars) about an axis parallel to the axis of rotation of the earth *(Fig. 7)*.

To prevent the introduction of gravity effects into the accelerometers, it is necessary to continuously correct the orientation of the platform for both of the above effects.

The correction for motion over the earth requires knowledge of the angular motion of the system. The radius of the earth is known and the distance traveled is available from the accelerometers themselves. If the distance traveled is divided by the radius of the earth plus the altitude above the surface, the resulting angle is precisely the angle through which the platform must be tilted to maintain the proper orientation. The output of the computer which performs this division is applied to the platform controls in such a way as to keep the accelerometers always properly oriented.

Similarly, the orientation can be corrected for earth rotation by supplying a signal which is a function of time and latitude of the system *(Fig. 8)*. It is apparent that an earth-stabilized platform will experience a component of the earth's rotation about its north-south axis, given by the cosine of the latitude, and a component about its azimuth axis, given by the sine of the latitude. The computer will compute the present latitude from the initial latitude and the second integral of the north-south accelerometer output. It will then resolve the constant earth rate

into north-south and azimuth components, and send the portions to the appropriate platform drives.

In any but the crudest applications, accuracy requirements make it necessary to take into account secondary effects due to the oblateness of the earth and due to the angular motion of any earth-fixed coordinate system (the well-known Coriolis effect). These effects require additional elements in the computer but introduce no new principles.

System Operation

The block diagram *(Fig. 9)* shows the essential elements of an inertial navigation system. For simplicity, a single-axis system is shown. Its operation can best be illustrated by considering the effect of acceleration of the vehicle in which the system is located. An acceleration to the right, for example, will be detected by the accelerometer. The output of the accelerometer will be doubly integrated, and the resulting distance information displayed for the operator. In addition, this information may be used, after any necessary computation, to provide angular correction information to the stabilized platform.

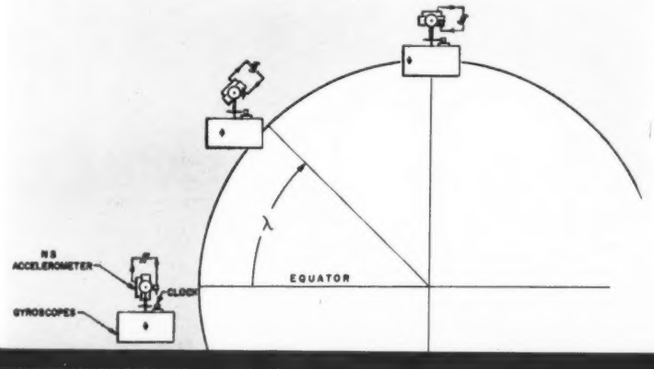
Errors

Any mechanical or electrical system can be expected to depart somewhat from perfect response to input signals. At first glance it appears that the performance of the inertial instruments (that is, the accelerometers and gyros) will have to be surpassingly good in order to provide accurate position information over a period of hours. It might be expected, for example, that a fixed platform tilt would cause an error to build up as the square of the time. [1] Similarly, gyro drift rate might be expected to result in an error that increases as the cube of the time. However, while it is true that the requirements on these instruments are severe, the curvature of the earth, together with proper design of the system, results in a limiting effect on system errors. This effect can best be illustrated by considering an example.

[1] $E = \frac{1}{2} \sin \Phi g t^2$, where E is error, Φ is tilt, g is gravitational acceleration, and t is time.

Fig. 16: This "equatorial mounting" carrying the accelerometer platform maintains the latter perpendicular to the local vertical, although the mounting itself is stabilized by a gyro system and the earth rotates beneath the system. The equipment shown was developed by the Autonetics Division of North American Aviation, Inc.

Fig. 17: The "equatorial mounting" also keeps the platform horizontal when the system moves over the curved surface of the earth. It can be so designed that the north-south accelerometer is always parallel to the earth's local meridian. The clock makes allowance for the earth's rotation.



A typical source of error in an inertial navigation system is an initial misalignment or tilt of the platform. If we examine qualitatively the effects of a tilt on a single axis platform which is stationary, as in a laboratory or a standing aircraft, we can get a picture of error propagation uncomplicated by aircraft accelerations and by interactions between axes of stabilization.

Let us assume *(Fig. 10)* that the system is started and aligned, with an initial incorrect tilt, Φ. The accelerometer registers an acceleration of $g \sin \Phi$, which is integrated and interpreted as a motion to the right. Hence, the computer sends a signal to the platform tilting it to the right through an angle corresponding to the spurious travel in that direction over the curved earth.

At a later time *(Fig. 11)*, the tilt to the right has equaled the misalignment angle, Φ, and the platform is now level. There is now no imput to the accelerometer. However, the first integral is still positive and the second integral is still increasing, causing a further rotation in the same direction, resulting in a sensed gravity component opposite to the original one *(Fig. 12)*. After a time the first integral is brought to zero and the platform comes to rest, this time with a tilt of Φ.

The reverse of the original situation now exists, and the platform is tilted back toward the original orientation *(Fig. 13)* and continues to oscillate in this fashion.

This illustration *(Fig. 14)* shows graphically the acceleration, velocity, position, and platform angle as compared with the proper values for these numbers as a function of time in the situation we have just described. The period of this oscillation, for a properly designed system is determined by the values of the earth's radius and g, and is 84 min. [2] It is, in other words, a Schuler tuned system. It is this phenomenon which makes inertial navigation practicable.

A null error (that is, an error in the location of the zero point), or a scale factor error in the accelerometer, will result in somewhat similar oscillating error curves *(Fig. 15)*. The phase relationships and the size of the mean error varies from one case to another, but the frequency and general form of the curves is similar. A drift in the levelling gyros introduces an error term which increases linearly with time, in addition to an oscillatory component.

For long navigation times, dynamical coupling among various parts of the system must be considered. Also error sources can usually be better described statistically than as constants. The net result of these two considerations is to reduce the long term buildup of error from that which might be expected on the basis of constant independent error sources.

Component Requirements

The critical elements of inertial navigation systems are the accelerometers and gyroscopes. The present state of the computer art, both analog and digital, makes it possible to meet the accuracy and capacity requirements by careful design.

The primary problem in the design of *navigational accelerometers* is achieving good null stability; however, resolution, linearity and scale factor accuracy are also serious problems. A null shift of .003 g (which might only represent one ten thousandth of an instrument range) will result in a navigational error of 10 nautical miles or 18.5 kilometers.

The primary problem in the design of *navigation gyros* is maintaining exceedingly small drift rates. For navigation applications, drift rates on the order of the tolerable position error rate are required. For example, a 0.01 deg/hr drift rate can result in a navigator error of 0.01 deg/hr or about 1 km per hour. Perhaps a better feeling for the magnitude of a .01 deg/hr drift rate can be gained by realizing that this represents one revolution in approximately four years.

*

We have seen that it is theoretically possible and also recently practicable to develop a navigational device which depends only upon its initial condition (position and velocity), and its accelerations relative to space in order to provide continuous position information. The advantages of such a system of navigation are numerous. It is independent of wind velocity and visibility conditions which often render more conventional navigation methods inaccurate or unusable. It is equally effective over land or water, during night or day, and places no restrictions on the course of the vehicle in which it is carried. Furthermore, since no external information is required after system activation, the system cannot be prevented from operating by electrical or magnetic fields of artificial or natural origin.

[2] $T = 2\pi\sqrt{R/g} = 5{,}060$ sec. – Ed.

Telecommunications and Electronics

Argus Eyes and Electronic Brains Protect the North American Continent

By Major Kurt Bolliger, Dübendorf, Switzerland

When President Truman had to announce to the American people in 1949 that Russia, too, had an atom bomb, preparations began for the erection of an electronic bulkwark along the main potential invasion front of the North American continent, the U. S.-Canadian frontier region. The *Pinetree Chain* of early warning stations *(fig. 1)*, on which "only" $250,000,000 was spent, seemed likely to provide sufficient warning of any approach by Tupolev Tu-4 bombers (copies of the B-29), which could just have made a one-way trip by the shortest possible route.

In reply, the Russians developed the *Badger* and *Bison* jet bombers and the *Bear* turboprop bomber, which they showed prominently at the Moscow air parades of the next few years. These three heavy bombers could reach San Francisco in above five hours, New York in seven and Chicago in eight, using departure bases in northeast Siberia, the central Arctic regions or the Murmansk area. In view of their speed, the range of the some thirty Pinetree stations was quite inadequate.

Accordingly, construction of a second radar belt, the *McGill Fence* or *Mid-Canada Line*, roughly along the 55th parallel in the north of Canada's inhabited provinces, was begun in November 1953. Against the obsolescent Tu-4s this chain would have provided the most northerly U. S. cities with a warning of roughly three hours; the *Bison* and the *Bear*, however, reduced this period to between 90 and 120 minutes. Large-scale evacuations within such short periods are simply impossible, as was conclusively proved by exercises organized to test the capacity of major exit roads (e. g., "Operation Alert" in 1955). Hence a warning chain still further north was decided to be indispensable.

As the erection of the Mid-Canada Line had provided ample experience of how to cope with the adversities of Arctic regions (which delayed completion until 1957), the third joint U. S.-Canadian entreprise, the *DEW Line* (Distant Early Warning) begun in the autumn of 1956, has been advancing at a pace that is scarcely credible by European standards. Estimated to cost roughly $1,000,000,000 in its final form (though other sources speak of only $600,000,000), the DEW Line stretches along the northern edge of the continent—i. e., roughly along the 70th parallel—from Alaska to Greenland, covering a distance of more than 3,000 miles. It will again raise the warning provided for the industrial centres around the Great Lakes and both the Atlantic and the Pacific coasts, to more than three hours, even against the most modern attackers. Bombers taking off from Siberia would be detected by radar after being in the air for about four hours. Large portions of the new line are said to be already in operation, and its extension from Alaska to the Aleutians is in progress.

In broad outline this three-stage warning system works as follows:

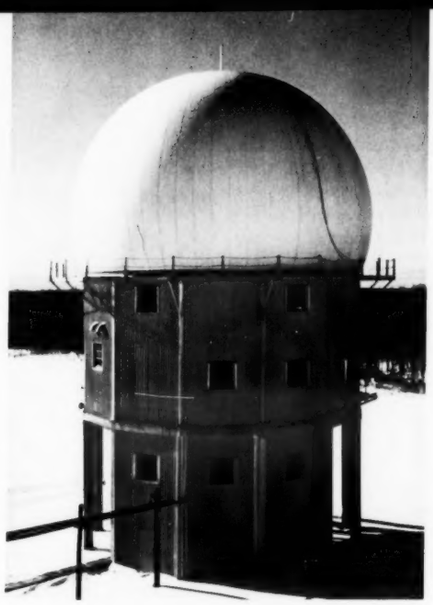


Fig. 1: Surveillance radar installation in the Pinetree chain, in the U. S.-Canadian frontier region.

- The DEW Line alerts both active and passive defence;
- Decisions and active defence measures are taken on the basis of information on direction and strength of attack provided by the Mid-Canada Line;
- The attacker is destroyed with the aid of the Pinetree Chain control system.

The new Russian bombers' increased range, however, would also enable them to *make a detour* around all three continental barriers and approach over the oceans. This would reduce the warning available to coastal cities to a few minutes. In the spring of 1955, therefore, the U. S. Air Force reverted to an earlier plan and began construction of a *chain of artificial islands*, the first of which, on George Bank some 120 miles off the coast of Cape Cod *(fig. 2)*, began operating its radar equipment early in 1956. Some thirty of these advanced bases, known as *Texas Towers* because of their similarity to the structures erected on the oilfields of southern coastal waters, will be built from Newfoundland to Florida, to protect the right flank of Continental Air Defense Command (CONAD). The time gained over coastal stations is about 15 to 20 minutes, which is less valuable for actual

Fig. 2: Operating base of 762nd Aircraft Control and Warning Squadron is Texas Tower No. 1, which stands on George Bank, a sandbank 100 ft. below sea level. The surveillance equipment (centre) and two altitude measuring installations under their hemispherical protective covers (left and right), are clearly discernible, together with three directional antennae for scatter communications with the mainland. The upper storey contains accommodation for roughly 70 men, who are flown out from their main base at North Truro, Massachusetts, on thirty-day tours of duty. The helicopter landing area is behind the antennae.

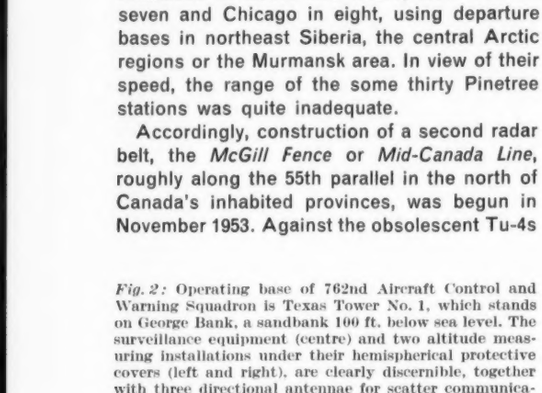


Fig. 4: One of the U.S.A.F.'s 8th Air Division flying radar stations, a Lockheed RC-121 *Super Constellation* (Naval designation WV-2), in operation.

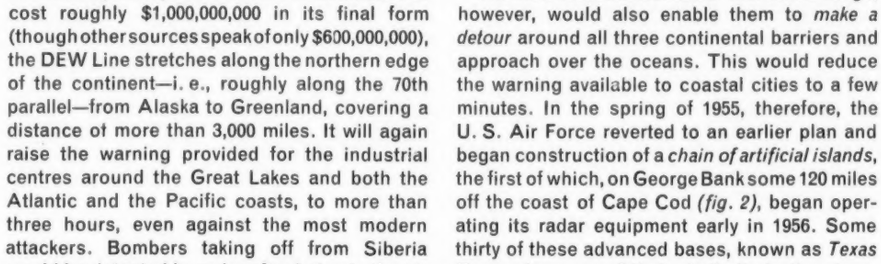


Fig. 3: Radar picket ship *U. S. S. Guardian* on the slipway at Norfolk, Virginia

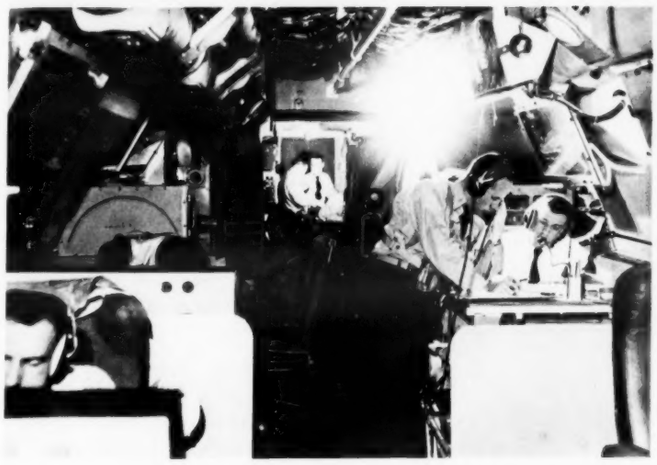


Fig. 5: The communications centre in a RC-121 (or WV-2). The radar observers work on either side of the centre aisle.

Fig. 6: Main post in the flying early warning station with central monitoring installation and other equipment, such as intercommunication, etc.

warning purposes than for defence operations. *Radar ships*, or off-shore pickets *(fig. 3)*, many of which also work for the civil air traffic control system and the meteorological service, are other sources of information for air defence and also improve range along the "water front".

In the two last-named cases, however, the antennae lie at best some 100 ft. above the sea, so that the *screen formed by the earth's curvature* in practice makes the performance of even the best equipment very problematical. Under normal propagation conditions there is a blind space around 35,000 ft. high for a range of 200 nautical miles. Low-flying aircraft—i. e. aircraft flying below 5,000 ft.—would therefore remain undetected until within ten minutes of the station. Hence there is a danger that crews who have never enjoyed the privilege of a Western education and thus are ignorant of the principles of fair play could simply slip through beneath the Atlantic network.

Protection against low-flying intruders—and a substantial increase in range—are provided by the 8th Air Division's *flying radar stations*. These are special versions of the Lockheed *Super Constellation* which bear the designation RC-121 with the U. S. Air Force and WV-2 with the U. S. Navy. Operated from both coasts, they supply a mobile early warning and fighter control network that is available twenty-four hours a day throughout the year. Each of these aircraft *(figs. 4—6)* carries roughly five tons of radar equipment and two complete crews (up to 31 men in total) and can operate at altitudes up to 25,000 ft., or the equivalent of an optical range of around 160 nautical miles. Despite the large bulges housing the search antennae above and below the fuselage, which have earned the aircraft the nickname of "pregnant goose", speeds of up to 300 knots are said to be possible when "action stations" are ordered. Wing-tip tanks with a capacity of 600 U. S. gallons each and an extra 1,000-gallon fuselage tank raise endurance for surveillance missions over the Atlantic or the Pacific to more than 20 hours.

*

These six main categories of sources of information for Continental Air Defense Command are supplemented by many others. For example,

Fig. 7: Plotting on the horizontal map at a control centre of conventional design.

Fig. 8: Experimental directional radio installation for a DEW line emplacement on the 70th parallel.

many areas within the United States are already well covered by radar, in particular the zone of dense civil air transport in heavily populated regions and the strategically vital areas such as Alaska or the atomic weapons production centres. The number of civil and military *search and height-finding radars* is constantly growing, as periodically reported in these pages. Finally, mention must be made here of the U. S.-Canadian *observer corps posts*, whose number is to be raised to 24,000 requiring a staff of roughly a million, most of them on a voluntary basis. Yet another source of information is *every flight plan*, which forms the basis of most civil flights and the large majority of non-tactical military flights.

It is obvious that so large a number of sources must provide an enormous volume of information. The conventional methods of "telling" and "plotting" which emerged from World War II and have remained standard practice to this day, are no longer adequate to handle this volume. The manual plotting of operations in the various sector centres becomes a problem as soon as more than one radar station or observer post is involved. In addition the system of telephoning situation reports from the lowest level (as in the "classic" fig. 7) to superiors and neighbours has very definite saturation limits, not to mention the inaccuracies and transmission errors which arise. On the next level these shortcomings not infrequently lead to serious confusion which may render it virtually impossible to eliminate overlapping reports or piece together partial reports. This type of experience has been known ever since 1939. What is more, the constant increase in radar range and the approximate doubling of aircraft speeds have made it increasingly difficult to produce an overall picture of the air situation which can be used as a basis for decisions. Nevertheless it was not until about 1950 that serious consideration was given in the United States to making the *whole system of communication and message evaluation automatic*. A joint planning and research group formed by the U. S. Air Force and the M.I.T. (Massachusetts Institute of Technology) finally produced the *SAGE project* (Semi-Automatic Ground Environment), i. e., the semi-automatic

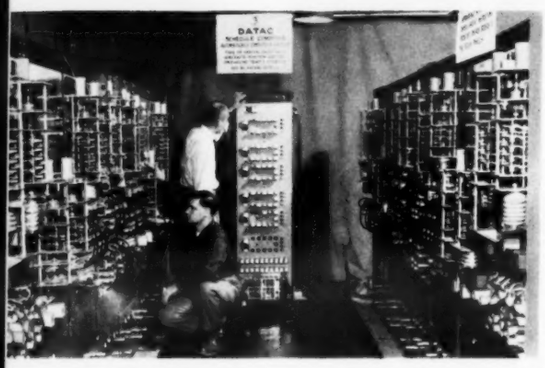


Fig. 9: The DATAC computer is the main component of the VOLSCAN system (AN/GSN-3) for the rapid guidance of returning fighter units: capacity up to 120 jet aircraft or 100 piston aircraft landings per hour.

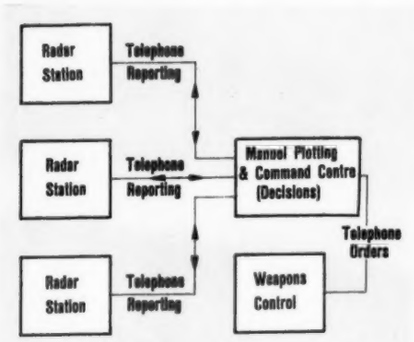


Fig. 10: Diagram of a conventional early warning system, in which situation reports are telephoned through to a centre and evaluated manually (manual plotting and command centre). Here the chiefs make their decisions and pass them by telephone to weapons control.

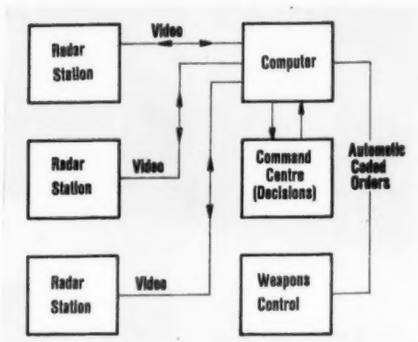


Fig. 11: Diagram of the SAGE system: all radar stations send their information in picture form (video) to a computer, which continuously informs the command centre of developments in the situation and makes allowance for the chief's decisions. The computer also passes automatic coded orders to the combat control centres.

linking of all land-based reporting and control facilities and of the fixed bases for the floating and flying stations.

*

SAGE merits particular attention in this Air Traffic Control issue because the reporting part of the weapons control system can be regarded as a prototype for an integrated air traffic control system. Although military traffic control must be concerned first and foremost with safeguarding military units, it is obvious, from the fact that both main types of operator must use the indivisible air space side by side in peacetime, that no air traffic control system can be built up without making allowance for *both* partners. SAGE can therefore be described as a test case for a control organization for the jet age in air transport.

The main emphasis in this system is on:

- a substantial expansion of the radar-controlled air space through reliable and instantaneous linkage;
- integration of the individual station areas through the automatic exchange of information all round;
- use of automatic computers to evaluate the centralized reports;
- automatic transmission and remote display of the tactical or traffic control orders from ground to air, thus relieving the increasingly congested voice channels (and the harassed crews).

The facilities required can be summarized as follows:

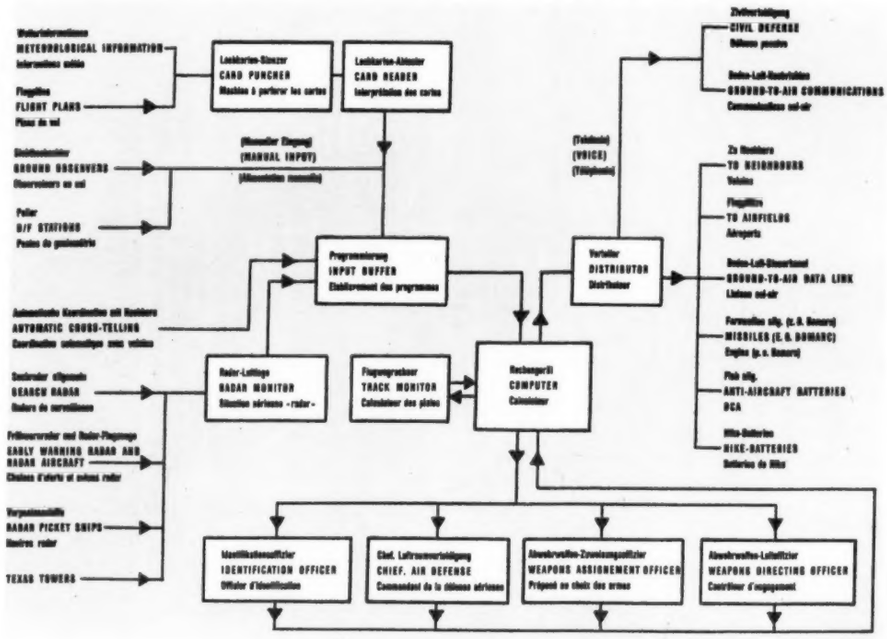
- *development of suitable compression methods* to reduce the broad bandwidths of video information to the band pass width of normal telephone lines;
- *connecting all reporting centres by wire and radio networks*, the latter of which generally work on the basis of radio links with extra-long range due to tropospheric or ionospheric scatter *(fig. 8)*;
- *development of a computer (AN/FSQ-7)* to handle incoming reports as regards collation, identification and coordination *(digital portion)* and to supply proposals for defence measures and the automatic execution of the latter on the basis of the command decisions programmed into the machine *(analogue portion)*;
- *development of linking systems for the individual defence facilities*, e. g. *TACAN Data Link* and *AN/GPA-37* interception system for the fighters, and the *Missile Master* for the anti-aircraft missile command centres. Indirectly, *VOLSCAN (AN/GSN-3)*, the fully automatic organization for returning fighter units *(fig. 9)*, must also be included among these linking systems, and it may also be assumed that certain civil projects, such as *Datamation* (semi-automatic transmission of flight plans), have been designed as supplements to this organization.

All these facilities are required before two basic principles of air defence can be put into effect: 1—*safety*, through the creation of an integrated air space control; 2—*concentration*, through the centralization of all ressources for fulfilling *one* mission in *one* hand. It will, however, be another few years before the joint air space control system for technical and tactical control is *fully* completed. Estimated total costs of SAGE are given as more than $1,000,000,000, of which $44,000,000 were spent in 1954, $144,000,000 in 1955 and $200,000,000 in 1956. Also of decisive importance is the application of certain basic principles, in particular the concentration of all appropriate forces from the Air Force, the Navy (picket ships, naval aircraft, aircraft carriers) and Army (anti-aircraft guns, *Nike* batteries) in a single overall organization, Continental Air Defense Command.

*

Fig. 10 illustrates the operation of a *conventional radar organization with any air force*, going back in essentials to World War II. The individual radar stations work out the local air situation on the spot and transmit it in the form of telephone reports to a common evaluating centre. Here the reports are entered on large vertical or horizontal maps. The chiefs assess the situation, make appropriate decisions and pass orders by telephone or R/T to the combat units. Constant changes in the situation, most of which are assessable only after some delay, necessitate constant changes in the orders issued. All this as a rule takes anything up to

Fig. 12: Diagram of a SAGE defence zone (altogether 32 such zones are planned for the United States).



one minute, so that the distance meanwhile covered by both hostile and friendly units can reach the magnitude of ten or more nautical miles. The total delays involved in this manual reporting and control chain can easily correspond to a distance of 20 to 40 nautical miles. Finally, a system of this kind requires an extremely large personnel, who rapidly become fatigued by the constant tension or whose attention wanders during quiet periods . . . an additional source of error which should not be underestimated.

Fig. 11 on the other hand outlines the basically new idea of the instantaneous semi-automatic network. All radar stations transmit their reports, in the form of selected overall pictures, direct to a computer which shows the command without delay how the situation is developing and what decisions are logical at any given moment. *Semi-automatic* in this connection means that the decision in favour of a given solution—perhaps from among several possible solutions—is not left to the machine, but is the responsibility of a commander. Once the decision is taken, it is dictated into the machine, which ensures that the order is executed, complete with any modifications necessitated by the enemy's subsequent behaviour. The selected defence units receive *coded orders* direct from the machine, which also arranges for anti-aircraft units to cease fire when it orders fighters to fly into the range of heavy A/A or rocket batteries. Finally, it keeps neighbouring centres constantly informed on situation reports received and orders issued, so that all operations can be passed on from one sector to the next without difficulties arising at the transition points. When the system is complete, 32 sectors, each with an electronic brain, will protect the whole of United States territory.

Fig. 12 shows a diagram of a SAGE defence zone. In the programming unit (input buffer) the radar information from all stations, the bearings obtained by the air traffic control authorities and the reports from ground observers are worked up into "*tracks*". Information on the movements of friendly aircraft—i. e., flight plans and current situation reports—are also programmed via punched cards. A computer then compares the overall situation with known friendly movements and submits any discrepancies to the *identification officer* as presumable enemy actions. If this officer identifies them as hostile, the decision to take defensive measures is, in principle, made by the *air defence commander* and passed to the computer. The analogue portion of the latter then tells the *assignment officer* what weapons can be used for the operation, on the basis of the information available to the machine on the position, range and alert status of all subordinate units. The *weapons directing officer* finally supervises the operation which is initiated and controlled by the machine. Coded orders are then passed to the defence centres for conventional anti-aircraft and missile batteries, as well as to the fighter units. Voice communications on hostile and friendly operations keep all other interested army and civil defence units informed *(fig. 12*, top right).

*

Homer relates how Troy was finally captured, after ten years of stubborn defence, by a stratagem. A Greek shock unit is said to have been smuggled into the city inside a large wooden horse, to prepare the way for the main army. In World War II the Belgian fortress of Eben Emael was captured by a handful of parachutists who dropped silently—and literally from the skies—in the rear of the armed defenders who were watching the Albert Canal. Declarations of war have gone out of fashion since 1939, and it is unlikely that a future aggressor would forego the advantages of surprise for the sake of "formalities" of this kind. It is thus understandable that the experts give that side the best chances which already has an integrated air space control system in peacetime and can deny use of its navigation aids to the enemy in good time.

Thus two more of CONAD's measures should be mentioned in conjunction with SAGE: *1. the creation of Air Defense Identification Zones (ADIZ); 2. preparations for all radio-electric transmitters to cease operations immediately on receipt of an alert (CONELRAD).*

Although the flight plans of all aircraft approaching the North American continent are received in advance of actual movements and are immediately programmed into the SAGE computers *(fig. 12)*, the allocation of each radar target detected to a given flight plan must be very carefully checked. Before setting out on Atlantic or Pacific flights, crews are therefore given detailed identification instructions to be followed exactly on approaching the ADIZ. *Fig. 13* illustrates such a *Multiple Corridor Identification System (MCIS)*, for aircraft approaching the East coast from the direction of Nova Scotia. Any aircraft which cannot identify itself or which makes errors in the procedure is entitled to an Air Force "guard of honour", the cost of which, however, is borne not by CONAD but by the erring airline. This cooperation between the Civil Aeronautics Administration and the military command centres in the United States in the interests of national security might well be copied in many European areas.

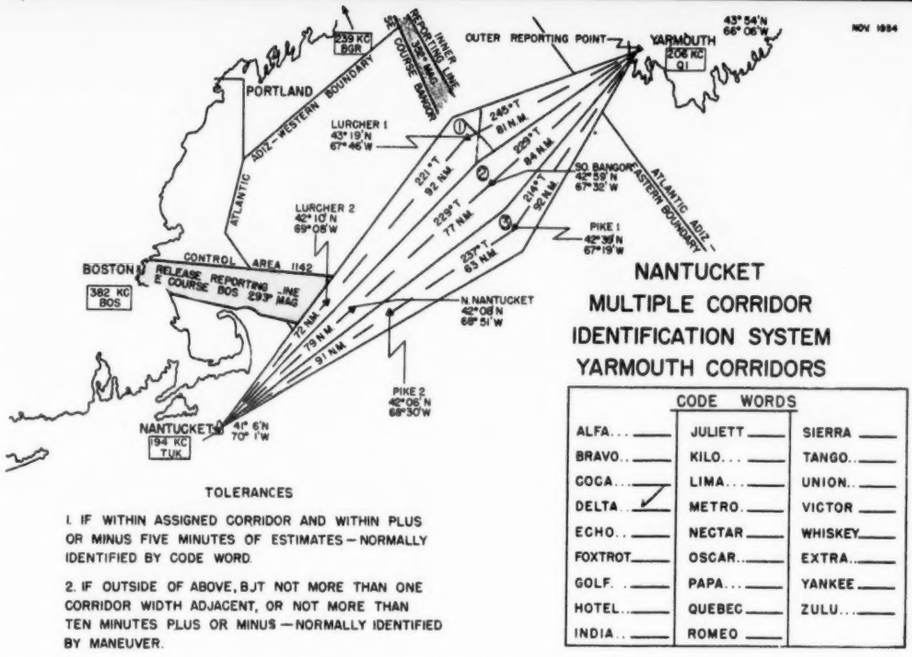
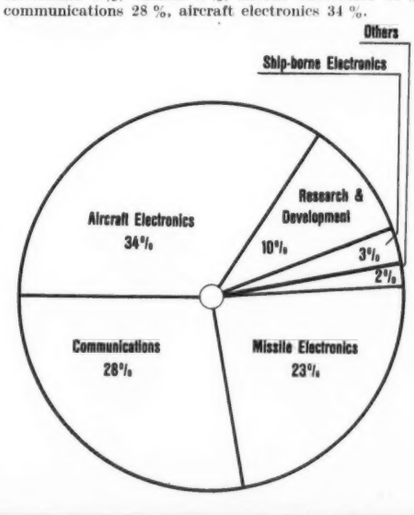


Fig. 13: Identification procedure for aircraft approaching the U. S. East coast from the direction of Nova Scotia. Every pilot must keep exactly to the prescribed corridor and transmit his code word (e. g., delta) on request. If he strays from the corridor, he must carry out one of six identification manœuvres (e. g., 45° turn, 2 mins. straight ahead, 90° turn, 2 mins. straight ahead, 45° turn).

In the 1955–56 fiscal year alone, no less than $2,733,300,000, out of total military procurement appropriations of roughly $11,900,000,000, was spent in the United States on electronic equipment, which was allocated as indicated in the diagram in *fig. 14*. If the construction, installation and operating costs of the early warning lines, command centres and weapons control systems are added, it becomes obvious that a *tremendous common effort* has here been made by taxpayers, science, economy and the military. All have the same mission, to defend the United States against air attack.

Fig. 14: During the 1955-56 fiscal year the United States spent a total of $2,733,300,000 on communications and electronic equipment. These credits were divided up as shown below: research and development 10 %, ship's electronics 3 %, various 2 %, missile electronics 23 %, communications 28 %, aircraft electronics 34 %.



Lockheed's Silver Jubilee

Lockheed Aircraft Corporation's annual report for 1956 has a cover printed in silver and bears the title "Our Silver Anniversary Report". This extensive brochure probably cost not much less to produce than *Robert E. Gross*, the real founder of the company and its Chairman today, originally put into the whole enterprise 25 years ago.

In 1932 Robert E. Gross built his first aircraft, the twin-engine *Electra 10* for a crew of two and ten passengers; price $50,000. In 1957 a new Lockheed *Electra* is nearing completion: 88 passengers, four-man crew, two hostesses; price roughly $2,000,000.

As the renewed use of the name Electra reveals, the company, despite its progressiveness, sets considerable store by tradition. Incidentally, the feeling for tradition is one of Bob Gross's basic traits.

Describing Lockheed's early history in April 1946, *Interavia* wrote:* "... In 1932 the brothers Allan and Malcolm Loughead, who had a company known as Lockheed on the American West Coast and had been building wooden aircraft with the names of stars *(Sirius, Orion, Vega)*, found they had run out of ideas and cash. Their business manager, Carl B. Squier, today Vice President and sales boss of the whole organization, recalled at this critical moment that a smart young businessman on the East Coast, Robert E. Gross, was looking for a job ... The latter joined Squier in investing in the company, with Squier putting in $4,000, and Gross $36,000. A team of three was formed, of *Robert E. Gross,* President, *Carl Squier*, the business manager, and *Hall L. Hibbard*, the young chief designer ..."

Here is another example of tradition: these three men still hold leading positions with the Lockheed organization, though of course they have gradually added other gifted, younger men to the staff. Eleven years ago *Interavia* paid tribute to Robert E. Gross from inner conviction and today welcomes the opportunity to congratulate him on his Silver Jubilee.

The 1956 Lockheed report throws considerable light on the history of the past 25 years, as the following sample comparisons reveal:

Robert E. Gross, founder and Chairman of the Board of Lockheed Aircraft Corporation.

The 20 employees of 1932 had grown by 1956 into a labour force of 60,000 persons. The original two investors, with their princely $40,000, have been joined by roughly 25,000 shareholders in a company whose latest book value is given as $385,000,000. The first Lockheed *Electra 10* has been followed by some 70 other aircraft types, many of which have also been produced in quantity. The non-existent order backlog of 1932 had grown into a backlog valued at more than $1,500,000,000 at the end of last year. Whereas Bob Gross and his handful of staff fought for every dollar in order to bring out their first aircraft 25 years ago, in 1956 they had to set aside more than $15,000,000 for taxation, and spent roughly $22,000,000 on research and development, yet could report a profit of $15,000,000 and pay shareholders dividends totalling $7,000,000.

The two other members of the "founding committee" of Lockheed Aircraft Corporation are still with the company, after twenty-five years: *Carl B. Squier*, originally business manager, today Vice-President and Assistant to the Chairman (left); *Hall L. Hibbard*, then chief designer, now Senior Vice-President.

The introductory paragraphs to the Lockheed 25th Annual Report are signed by *Robert E. Gross*, who is now Chairman of the Board, and by his younger brother *Courtland S. Gross*, today President of the company: "... Looking forward to the next quarter century, during 1956 we brought in over a billion dollars in new orders ... Two-thirds of our unfilled orders is in five new types placed in production during the past couple of years. In 1956 we flew five airplanes and three missiles for the first time, and another plane took to the air in January 1957. We gained system management of three highly advanced military programs, two in missiles and one in nuclear propulsion ... And we made several organization changes to adapt our company to tomorrow's opportunities."

The report adds elsewhere that new military orders received in 1956 totalled about 1,200 aircraft, including many hundreds of F-104 *Starfighters,* additional T-33A trainers for the Air Force, as well as T2V-1 *Sea-Stars* for the Naval Air Reserve Training Command, new orders for the WV-2 *(Super Constellation)* early warning aircraft and P2V-7 naval patrol aircraft, and finally the C-130 *Hercules* four-turboprop military transport. "Early in 1957 we began construction of a prototype jet utility trainer-transport that the armed forces have indicated an interest in buying on an 'off-the-shelf' basis. We believe ultimately such a plane may attract important orders for business and corporate executive users. Our multi-engine plane, designed to carry a crew of two and from eight to 10 others, is due to fly this fall.

"We gained six new customers in 1956 to raise our commercial backlog to $444,871,000, our top year-end figure ... Our backlog now lists 216 commercial transports. Airlines bought 38 more prop-jet *Electras* to raise orders to 133, valued at

* Published only in French and German.

$247,000,000 . . . We received orders for 11 more Model 1049H and nine 1049G Super Constellations . . . There are now 365 *Constellations* in service on 32 airlines in 21 countries . . ."

"Preparing for the future . . . Rapid growth of our Missile Systems Division since we created it as a separate operating division three years ago has been most encouraging. Sales now equal in dollar volume those of the whole aircraft industry 20 years earlier. Employment nearly doubled in 1956 and is currently four times as large as that of our entire company 20 years ago . . . Work is proceeding on a dozen major and several minor missile programs, only three of which we have been able to announce. One is the *Polaris*, the Navy's intermediate-range ballistic missile on which we are the major contractor. The second, our X-7 supersonic ram-jet test missile, is one we have built by the dozens . . . The third is our X-17, a hypersonic ballistic rocket to study heat and friction problems that missile warheads encounter in re-entering the earth's atmosphere . . ."

The picture would be incomplete without a few lines on the company's financial development, which is illustrated by the following figures—also taken from the Annual Report—for 1947, compared with 1956:

	1947	1956
Sales	$134,364,000	$ 742,591,000
Earnings after taxes	$ (2,472,000)	$ 15,073,000
Taxes	$ (313,000)	$ 15,280,000
Dividends	—	$ 6,813,000
Order backlog	$139,002,000	$1,597,523,000
(Incl. commercial)	$ 20,261,000	$ 444,871,000)
Employees	14,555	61,032

Space limitations make it impossible to go into the 32-page Lockheed jubilee report in as great detail as it deserves.

A handful of men in an aircraft shed in Burbank, California, has grown into an enterprise which is today "one of the 30 largest American industrial organizations". Lockheed products, both civil and military, are used throughout the world. The name of Lockheed is today carried night and day over all continents and oceans. How has this come about?

Basically, the company's success is largely attributable to the courage, good luck and energy of one man, and we can do no better here than repeat portions of Robert E. Gross's career as described in these pages in 1946:

. . . His first customer was Tony Fokker, of whom it was said on his untimely death that there were in aviation many less gifted and less capable than he. Fokker acquired the first Lockheed licence in 1933, and his down payment of $60,000 provided the real starting funds. The Fokker order for Lockheed *Electra 10s* was more or less taken over by the Polish Government of the day, and it was the Polish airlines which first operated this type of aircraft.

Left: C. L. "Kelly" Johnson, Vice-President, Engineering and Research; right: Leonard K. Schwartz, Director of Marketing.

Then came a decisive stroke of luck for Bob Gross, when a sports-loving young millionaire by the name of Howard Hughes —relatively unknown in those far-off pre-war days—undertook a successful round-the-world record flight in a later Lockheed twin-engine commercial aircraft, the Lockheed 14, thus making himself and Lockheed internationally famous. As an indirect result of this connection between Lockheed and Hughes, the first modern long-range commercial transport with pressure cabin, the Lockheed 049 *Constellation*, was brought out in the early post-war years. Howard Hughes had meanwhile become a major shareholder in T.W.A. and had proposed to Bob Gross that he should develop an aircraft of this category to enable T.W.A. to outdo its rival, American Airlines. Again indirectly, this first Lockheed *Constellation* was the reason why Douglas developed the DC-6, DC-6B and DC-7 family for T.W.A.'s competitors.

Returning to the logical sequence of events, the Lockheed 14 flown by Howard Hughes before the war was the first really big success for the still more or less struggling company. By that time the war was approaching. The Royal Air Force had pilots but too few aircraft, and Norman Ebin, Lockheed representative at the time, proposed to the British that the Lockheed 14 could be developed without delay into a "first-class reconnaissance bomber" and be put into production. No sooner said than done. The Lockheed 14 became a combat aircraft under the name of *Hudson*, of which the company built 2,900—1,298 of them going to Britain. The rest of the story is well known.

Courtland S. Gross, President of Lockheed Aircraft Corporation.

Whether by good luck or good management, Robert E. Gross has always managed to surround himself with a first-class team. Vice-President Engineering Hall L. Hibbard was later joined by a capable young engineer named C. L. ("Kelly") Johnson, now Vice-President, Engineering and Research, who had worked on the *Hudson* and has recently shown what he is capable of in the Lockheed F-104. To him must go at least part of the credit for the company's military development. Carl B. Squier, the first Vice-President, Sales, now heads a staff of sales "big shots", among them *Leonard K. Schwartz* who helped to open up the overseas market after the death of the unforgettable European representative A. F. E. McInerny.

It might be said that such a story of industrial development is by no means sensational in the United States, since after all—to remain within the aircraft industry field—other firms, such as Douglas, United Aircraft or today's Convair sprang from small beginnings. But these companies, which are also older, were in some cases backed in the early days by the big banks. Behind Bob Gross and his two companions stood . . . nothing.

Unknown 25 years ago, he has succeeded in utilizing the capital which gradually flowed in to him to such good effect that his company ranks today among the world's elite, not least from the engineering point of view. That he has also become a patron of the arts along the way should not be surprising, since this is a hobby many wealthy men indulge in. Finally, it must be counted to his credit that he has always shown a flair for the designs of the future, that he was the first to make the transition back to peacetime conditions with his modern aircraft for the airlines, and that above all he is one of the most likable characters in the whole of the aviation world.

All congratulations now reaching him have been well earned during the past 25 years! *EEH*

General Dynamics Reports Record Resultats — but Loses its Founder John J. Hopkins

"... The American industrialist who has been the greatest advocate of the use of atomic energy, including-aircraft engines, is a frankly armament industrialist to judge from the structure of the group he heads: he is John Jay Hopkins, President of General Dynamics Corporation ... Hopkins has proclaimed himself a champion of the atom and stated not long ago that he was convinced he would live to see the first atomic aircraft fly ..."

(*Interavia*, No. 11, 1955).

John Jay Hopkins, Chairman and President of General Dynamics Corporation, who died on May 3rd, 1957.

John Jay Hopkins, who was so often proved right during his ten years at the head of General Dynamics, the corporation he had himself founded, was mistaken on this last point: on May 3rd, 1957, two days after his re-election as Chairman, he succumbed to a malignant disease in Washington's Georgetown University Hospital. He did not live to see the first atomic aircraft fly. But perhaps in a few years' time the "John Jay Hopkins Laboratory" for theoretical and applied nuclear research now being set up in La Jolla, California, may discover ways and means of removing the scourge of humanity to which Hopkins fell victim.

The introduction which Hopkins wrote on March 25th, 1957, for General Dynamics Corporation's eleventh annual report now strikes a somewhat tragic note: "The conclusion of the year 1956, marking for me a full decade of responsibility for executive direction of our enterprise, is an occasion appropriate ... for reflection upon those events ... that have characterized our progress ... For the first time, consolidated net sales of General Dynamics exceeded the billion dollar mark ..."

*

Born in Santa Ana, California, on October 15th, 1893, Hopkins studied law and, after serving in the U. S. Navy during World War I, settled in New York as a lawyer. He later became legal adviser to Electric Boat Company, manufacturers of submarines, whose Board of Directors he joined in 1937. Here he had found the real field for his activities. By 1942 he was Vice-President of Electric Boat and by 1947 he had advanced to the position of Chairman of the Board. A year earlier he had acquired Canadair Limited, Canada's leading aircraft manufacturers, for his company. But the successes scored in American nuclear research and electronics spurred him on, and it became his ambition to create an organization which should stand at the head of this development. He bought up other companies, coined the name General Dynamics Corporation for the new organization in 1952, and in 1953 added to it Consolidated-Vultee Aircraft Corporation (by acquiring a decisive minority holding from New York financier Floyd Odlum) which he then ran as a division of General Dynamics.

Aircraft manufacture, research and development of guided missiles, submarine construction, research and development in all fields of atomic energy and electronics—such is the heritage which John Jay Hopkins has left behind in General Dynamics.

*

The eleventh annual report published by General Dynamics Corporation and its six research and production divisions* could no longer be presented to shareholders by Hopkins personally, but his own message to share owners contains the following words:

"While aircraft sales continued to be the Corporation's principal source of revenue, substantial increases were reported by the other operating divisions in sales of missiles, submarines, electric motors, telephone, electronic and sound equipment ..."

A list of the various divisions' most striking successes reads as follows:

Aircraft

Convair B-58 *Hustler*, America's first supersonic bomber.
Convair F-102A, U.S. Air Force supersonic interceptor.
Convair F-106A, development of the F-102A.
Convair 440 *Metropolitan*, twin-engine commercial transport.
Convair 880, new four-engine jet commercial transport.
Canadair F-86 Mk. VI *Sabre*, jet fighter (North American Aviation licence).
Canadair CP.107 *Argus*, four-engine naval reconnaissance aircraft (development of the Bristol *Britannia*).

Missiles

Convair *Terrier*, surface-to-air supersonic missile for the U.S. Navy.
Convair *Atlas*, I.C.B.M., big research and production programme.

Shipbuilding

U.S.S. *Nautilus* and *Seawolf*, atomic-powered submarines, handed over to the Navy for trials; others in preparation.

Atomic energy

"John Jay Hopkins Laboratory" for theoretical and applied research, being built at La Jolla, Calif.
Contracts from the Atomic Energy Commission for the development of an atomic powerplant for super tankers.
Atomic reactor, due for completion this year.

Electronics

Wide range of equipment; new plant at Rochester, N.Y., acquired as Electronic Center; etc. etc.

The report does not reveal what the share of these various branches is in the sales and profit of the Corporation as a whole.

On the other hand, the closing figures for the year speak plainly, especially when compared with those for 1955 and 1946.

	1956	1955	1946
Sales	$1,047,818,510	$ 687,274,182	$14,368,954
Net income	$ 31,946,995	$ 21,254,386	$ 1,547,586
Taxes	$ 31,850,000	$ 23,000,000	($ 1,200,000)
Dividends	$ 13,255,617	$ 10,807,177	—
Backlog	$2,195,000,000	$1,610,000,000	$ 4,541,000
Shareholders	40,050	31,900	5,500
Employees	94,300	70,500	3,658

* General Dynamics comprises six divisions. Canadair Limited, being outside the United States, is independently run, while the five other divisions, Electric Boat, General Atomic, Electro Dynamic, Convair, Stromberg-Carlson, are all part of the parent organization.

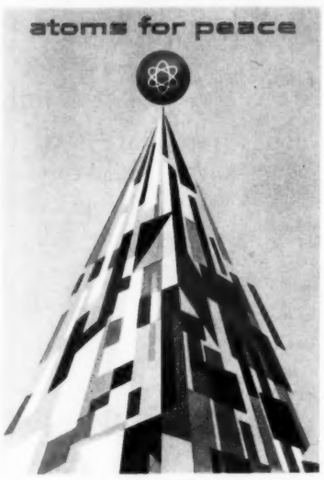
With all due caution it may be said that the atomic energy and electronics sides of the General Dynamics organization are still in the build-up stage, while the two divisions concerned with aircraft production and missiles—Canadair and Convair—are at present the real "milk cows".

Canadair Limited, acquired in 1946, is a prime example of cautious planning; in fact, one is tempted to say it is run by "Canadian Scotsmen". It has never engaged in irresponsible gambles, but has consistently moved on step by step to successful developments of proven types.

During the war the company devoted itself entirely to military work for the British Commonwealth. After the war it built first the Canadair *North Star*, which enabled B.O.A.C. to maintain its overseas services. Next came licence production and development of the proven North American F-86 *Sabre* jet fighter, which Canadair has supplied not only to the Royal Canadian Air Force, but also in large numbers to foreign countries; latest customer for this aircraft is West Germany. Finally, Canadair acquired production rights for the Bristol *Britannia* in the North American continent; a production order for the CP-107 *Argus* naval patrol aircraft is in hand, and other developments with Bristol *Orion* propeller turbines, the CC-106 military transport and the CL-44 commercial transport, are planned.—Canadair is thus a model of steady economic progress in the aircraft manufacturing field.

The *Convair Division* is today undoubtedly the real backbone of the General Dynamics organization. Of the Corporation's total labour force of roughly 95,000, somewhere about 60,000 are employed by Convair alone. It has the most costly and many-sided "aerodynamic" developments—bombers, fighters and missiles—in production or under test, and plays a vital part in equipping the United States' arsenal.

Its early history, however, reads like a novel of the real pioneering days . . . On May 29th, 1923, one Major Reuben Hollis Fleet set out with $60,000 to found Consolidated Aircraft Corporation, in the State of Nevada. The $60,000 of 1923 had turned into a value of at least $250,000,000 by 1946, or four thousand times the original investment. In 1929 Reuben Fleet began to develop his company financially: the original 600 shares of $100 each became 1,200,000 shares with a par value of $1—though



"Atoms for Peace," General Dynamics Corporation's poster for the 1955 Geneva atomic exhibition.

selling price was $25 each. Thus anyone who had bought a $100 Consolidated share in 1923 received $50,000 for it in 1929. The investment-hungry public was offered 82,175 of such "new" shares. By the eve of the 1929 crash, the share price had risen from $25 to $44.50, or only 89,000% of the original value on the company's foundation. True, this price dropped from $44.50 to $0.75 during the early part of the economic crisis, which doubtless did not greatly please the new shareholders. But later it began to rise again.—This was the financial beginning of Consolidated Aircraft, and it sounds rather like a miracle.

The miracle, however, was not finished, for Reuben Fleet was not only a shrewd financier, but also proved to be a gifted industrialist. Initially his main customer was the U. S. Navy, for whom he brought out the twin-engine PBY reconnaissance flying boat before the war. This aircraft became a world-wide success, and is still flying today. During the war he then built B-32 *Liberator* bombers in large numbers for the Air Force.

J. Geoffrey Notman, Senior Vice-President - Canadair, General Dynamics, and President and General Manager of Canadair Limited, Montreal.

When the war was over, Reuben Fleet did the cleverest thing a wealthy man can do. He retired from the company and merged it with the neighbouring Vultee Aircraft Company. The resulting Consolidated-Vultee Aircraft Corporation in due course became the Convair Division of General Dynamics.

That Consolidated Aircraft and Consolidated-Vultee Aircraft changed ownership and management more than once—first the New York banker Victor Emanuel of AVCO and later Floyd Odlum of Atlas Corporation were the chief shareholders—is today irrelevant, now that Convair is a vital division of General Dynamics. What the company is producing and planning has already been mentioned. It is among the first rank of American aircraft manufacturers.

*

John Jay Hopkins, the lawyer and industrialist, had the good fortune to be able to build up an organization which today is the seventh largest contractor to the U. S. Government. His death at the age of 63 robbed this exceptionally gifted man of the fulfilment of one of his dearest wishes, for which he has perhaps done more, talked more and written more than any other living man. *Atoms for Peace* was his slogan; in fact it is widely suggested that he was the author of the expression, which was taken as name of the first international atomic conference, held in Geneva in 1955. Although the political developments of recent years did not permit him to harness his organization to the cause of peace to the extent he would have wished, he will still go down in history as one of the apostles of the peaceful use of nuclear energy.

When he died on May 3rd, he had evidently prepared for the worst and made plans for a successor. The directors' meeting on May 1st elected, at his request, *Frank Pace Jr.* as President, i. e., as his direct representative at the head of the Corporation. Pace had been a close business and personal associate since 1953. A Major in the Army Air Force during World War II, the former lawyer had served in several different ministries under the Truman administration: he had held a key position under the Attorney General, in the Post Office Department and the Department of the Treasury and finally, in 1950, became Secretary of the Army.

Pace is 44 years old and is marked out to continue General Dynamics along the lines desired by its founder. *EEH*

What's in the Air?

Extracts from Interavia Air Letter, *daily international news digest, in English, French and German. All rights reserved.*

Rotor-Craft *Pinwheel* light one-man helicopter with rocket-driven rotor.

AIRPORTS

● **Three of the four Metropolitan area airports** operated by the Port of New York Authority handled a combined total of 12,109,583 passengers in 1956, an increase of 11.6% over the 1955 total. La Guardia Airport handled 5,403,239; New York International (Idlewild) 4,490,050; Newark (New Jersey) 2,183,256. Teterboro Airport, New Jersey, not serviced by scheduled carriers, had 222,187 aircraft movements in 1956. Air cargo at all four of these Port Authority-operated airports totalled more than 323,000,000 lbs in 1956, up 6.9%; mail rose by 7.4% to 92,800,000 lbs.—In 1956, the Port of New York Authority spent $ 33,200,000 on airport improvements. This year, capital expenditures are expected to reach $ 90,900,000. Of the total passengers at La Guardia, Idlewild and Newark, 10,579,988 were domestic and 1,529,595 overseas passengers.

● **The expansion of London Airport** is the subject of a report prepared by a committee appointed by the Ministry of Transport and Civil Aviation. The committee's recommendations envisage the expenditure of an additional £ 10,000,000 over and above the £ 20,000,000 already spent and the £ 6,000,000 allocated. The Central Area will be considerably enlarged, with a number of new buildings for various airlines, and long fingers will be added to the Central Terminal building. — With the growing congestion at London Airport, it is thought that Gatwick Airport, instead of being an alternate, may well become the main United Kingdom airport for European and domestic traffic. In this case, London Airport would probably be known as "London International" and Gatwick as "London Continental".

● **A tax-free shop** has been opened at Amsterdam-Schiphol Airport, according to a K.L.M. Royal Dutch Airlines announcement. Travellers bound for the United States are enabled to buy cigarettes, cigars, tobacco, liquor, liqueurs and chocolate duty free. Nationals of all countries except the Benelux countries may avail themselves of the facilities offered by the shop.

● **Ostend-Middelkerke Airport** is to get two new runways next year—one 2,400 yards long, and the other 3,060 yards. The new runways will make it possible for Ostend to be used as an alternate for Brussels-Melsbroek. Ostend is less than an hour's journey by rail from Brussels. This year it is estimated that Ostend Airport will handle 80,000 passengers, compared with 52,000 in 1956, 28,000 in 1955 and 16,000 in 1954.

Two new Vice-Presidents of Douglas Aircraft Co.: M. E. Oliveau, Director of the European Division, Geneva, Switzerland (left) and John A. Dundas, General Counsel.

Colonel Howard L. Burris, Air Attaché to the U. S. Embassy in Berne, has taken up a new appointment as Chief of International Liaison with the U. S. Air Force at the Pentagon. His successor in Berne is Colonel John C. Habecker.

Air Vice Marshal Douglas Griffith Morris heads the new organization at the Air Ministry to coordinate the introduction of defensive missiles.

● **Palermo's international airport** is to be built at Punta Raisi. It is envisaged that the State should provide a credit of 2,000,000,000 lire, repayable within ten years, for the purpose. The Province of Sicily is to bear 40% of the total cost.

● **Beirut-Khaldeh Airport,** which was modernized soon after the war, is to be expanded still further, in two stages. The first stage will involve lengthening of the 7,810-ft. north-south runway by 1,215 ft. at the southern end. The northeast-southwest runway, also 7,810 ft. long, will be extended by 660 ft. towards the northeast and 2,030 ft. towards the southwest to a total length of 10,500 ft. A taxiway 1,200 ft. long and 75 ft. wide linking the two runways will also be built. Finally, the aircraft parking area will be extended and its capacity (at present 8 or 9 aircraft) will be trebled. The second stage will see the lengthening of the north-south runway to a total of 9,810 ft. and the construction of five hangars to house DC-8s and Boeing 707s.

AIR TRANSPORTATION

● **Trans World Airlines'** first jet and propeller-driven "Flying Maintenance Base" has been commissioned at Orly Airport, Paris. Rebuilt from a Fairchild C-82 *Flying Boxcar,* the aircraft carries some of the most modern equipment available. A Fairchild J44 jet engine is mounted on the fuselage amidships, while Wright CB16 engines similar to those that power T.W.A.'s Martin airliners have replaced normal engines for a C-82. The "Flying Maintenance Base" is designed to shepherd T.W.A.'s airliner fleet throughout Europe, the British Isles, North Africa and the Middle East. The aircraft carries the latest type of radio and electronic equipment similar to that to be installed in T.W.A.'s fleet of Boeing jetliners. Huge clam-shell doors and heavy automatic loading equipment will enable three-ton spare engines to be unloaded in eight minutes or less.

● **Capital Airlines** announced early in May that it had shelved plans to buy 15 additional Vickers *Viscounts* and 14 de Havilland *Comet 4s* and *4As.* Capital's President, J. H. Carmichael, cited disappointing first quarter financial results, labour difficulties and uncertainties over whether the company would be allowed requested fare increases as the principal reasons for the decision. He indicated that Capital might purchase the *Comets*—

Fairey Aviation Company Ltd. – Appointments in the Engineering Division: Dr. G. S. Hislop to be Deputy Chief Engineer, retaining his position as Chief Designer (Rotating Wing); D. Wakeford to be Chief Designer (Fixed Wing); C. W. Cowle, to be Deputy Chief Designer; G. M. Spinks and W. C. Scott to be Assistant Chief Designers.

Vertol 76 convertiplane with Lycoming T53 gas turbine. Bench tests are now being made.

on which delivery was to have begun in the autumn of 1958—at some later date.

● **Trans Canada Air Lines** has exercised an option to increase its original purchase of four DC-8s to a total of six, all of them to be powered by Rolls-Royce *Conway* engines. Delivery of T.C.A.'s DC-8s will begin late in 1959.—Douglas Aircraft Company reports that 121 DC-8s have now been ordered.

● **Linee Aeree Italiane's** revenues for 1956 amounted to 898,158,048 lire, against expenditures of 896,845,342 lire, leaving a surplus of 1,312,706 lire which has been transferred to the reserve fund. The following operating figures have also been released (with percentage increase over 1955 in brackets): kilometres flown 11,255,418 (+5.2), passengers carried 277,808 (+17.6), passenger-kilometres 238,605,729 (+5.4), freight and express 3,729,496 kg (+11.9), mail 1,239,496 kg (+20.3), freight and mail tonne-kilometres 27,558,502 (+6.8).

● **Transports Aériens Intercontinentaux** performed 27,715,400 passenger-kilometres in 1956. The average distance flown by each passenger was 5,052 km. With the inauguration of the Paris-Auckland route, T.A.I.'s network has been brought up to 55,000 km. By improving overhaul and maintenance methods at its Orly workships, T.A.I. was able to raise the average flying time per aircraft each day to 11 hours 33 minutes, an improvement of 21 minutes over the average for 1955, when the company received a special award from Douglas Aircraft Company for the best utilization of a DC-6B.

● **Olympic Airways S.A.,** which took over last April 6th the domestic and international network previously operated by National Greek Airlines T.A.E., has been admitted to active membership in the International Air Transport Association.

● **A second Fokker F.27 Friendship** has been ordered by the Australian Department of Civil Aviation for delivery in August 1959. The first F.27 ordered by the Department is scheduled for delivery in July 1959. Both aircraft will be used for regular flight tests of Australian air radio, navigation and safety aids, and will carry about one ton of special test equipment. After delivery of the F.27, the Department will dispose of three DC-3s at present used for flight checks of ground installations.

● **The West German Transport Ministry's** Air Transport Advisory Council has proposed the establishment of a national airline pilots' school (Deutsche Verkehrsfliegerschule) which would replace the flying school organized by Lufthansa in Bremen. The necessary funds would have to be provided jointly by the Federal Government and by the provinces. The Council also recommended the construction of new terminal buildings in major towns in order to cut waiting time on the ground to a minimum. A special committee set up by the Council will deal with aircraft types of the future, including helicopters, VTOL and STOL machines.

INDUSTRY

● **A new method of launching high-speed aircraft** from short airfields has been developed for the U.S. Navy by All American Engineering Company, Georgetown, Delaware. It is known as the "turbo-catapult". Powered by six jet engines, the turbo-catapult develops 60,000 h.p., and can be dismantled with comparative ease and transported by air to airfields where it is needed. Navy aircraft using this catapult have been launched into the air in less than one-fifth of their normal take-off runs.

● **Rocketdyne Division** of North American Aviation Inc. is developing high-thrust rocket engines for the *Jupiter* intermediate range ballistic missile, according to a U.S. Army release. Identification of Rocketdyne's role in the *Jupiter* programme brought to five the number of major missiles for which the North American Division is supplying rocket power. Previously announced were large liquid-propellant engines for the Air Force SM-64 *Navaho* intercontinental missile built by North American, the Army *Redstone* medium-range ballistic missile built by the Army Ballistic Missile Agency and Chrysler Corporation, the Air Force *Thor* intermediate range ballistic missile built by Douglas Aircraft Company, and the Air Force *Atlas* intermediate range ballistic missile built by Convair.

Åke Rusck, Director General of the Swedish Water Power Board, succeeds Henning Throne-Holst as Managing Director of S.A.S. on January 1st, 1958.

H. M. Horner, Chairman of United Aircraft Corporation (left) receives the insignia of Chevalier of the Legion of Honour from Comte Jean de La Garde, French Minister Plenipotentiary.

European Civil Aviation Conference, Madrid: inaugural speech by I.C.A.O. Council President Walter Binaghi on April 24th, 1957.

John E. Canaday has been elected Vice-President in charge of public relations for Lockheed Aircraft Corporation.

Howard W. Merrill, Vice-President of the Martin Company and General Manager of the Baltimore Division.

Link Aviation Inc.: Edgar Allen «Pete» Goff, Jr. has been named Assistant to the President. An active pilot or reserve pilot from 1918 to January 1957, he has logged more than 17,000 flight hours.

An S.A.C. bomber was refuelled in flight over the United States on an average every four minutes during 1956. Today in-flight refuelling has also become routine for fighters Left: two North American F-100 *Super Sabres;* right: an AJ-2 refuelling a U. S. Navy Chance Vought F8U-1 *Crusader.*

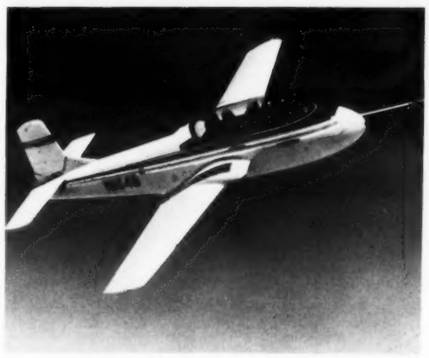
● **PacAero Inc.,** of Santa Monica, California, has acquired the right to manufacture and sell the Napier "Spraymat" electrical system of de-icing in the United States, its territories and possessions. Napier is to supply all the necessary drawings, reports, technical information and assistance needed to enable Pac Aero to establish both manufacturing and servicing facilities, and will take all responsible steps to promote the sale of "Spraymat" by Pac Aero. For its part, Pac Aero will make available to Napier details of all refinements and improvements which may result from development processes applied to the system by the American company.—The agreement between Napier and Pac Aero is for a period of ten years.

● **Igor Sikorsky** retired from his post as Engineering Manager of Sikorsky Aircraft Division of United Aircraft Corporation at the end of May, but will remain with United Aircraft for an indefinite time as a consultant.

● **The annual light aircraft display** at Venice has been cancelled this year.

FLYING EQUIPMENT AND POWERPLANTS

● The *Hispano Suiza R-804* jet engine (seven-stage axial compressor, annular combustion chamber, single-stage turbine) derived from the R-800 model, has a take-off power of 3,307 lbs. thrust at 12,000 r.p.m.; climb performance is 2,976 lbs. thrust at 11,630 r.p.m., and cruise power 2,646 lbs. at 11,250 r.p.m.; weight 678 lbs. without jet pipe. The R-804 can also be equipped with a reheat system which raises static thrust by 35% at sea level.



The Beechcraft 73 *Jet Mentor* two-seat jet trainer is now being built under licence by Canadian Car Company Limited, Montreal.

● Having completed the first phase of tests, the *Dassault Mirage III* delta-wing interceptor is undergoing modifications. A SEPR rocket motor is being fitted underneath the fuselage, which will greatly increase the aircraft's range of action at very high altitudes.—In a later version the *Mirage III* will be fitted with a SNECMA-ATAR 9 jet with reheat, of 13,000 lbs. thrust, instead of the present reheat ATAR G which has a thrust of 9,700 lbs. This version, which will have a speed in excess of Mach 2, will be equipped with a G.A. Marcel Dassault radar system, consisting of a target search radar and fire control radar.

● A new version of the *Tupolev Tu-104* twin-jet Russian commercial transport is shortly to go into service with Aeroflot and the East European airlines. The new version will have accommodation for 70 passengers, and be appreciably more powerful than the older model.

● *A small helicopter,* featuring simple structure and low procurement and operating costs, is said to have been developed by V. Vinicky, a Russian designer not hitherto mentioned. According to press reports, the type is fitted with a 260 h.p. engine, has a three-blade main rotor 36 ft. in diameter and has a design cruising speed of approx. 60 knots for a gross weight of 2,865 lbs.

● *Kaman Aircraft Corporation* is developing a new STOL aircraft, with gas turbines, under contract to the U.S. Navy Bureau of Aeronautics.

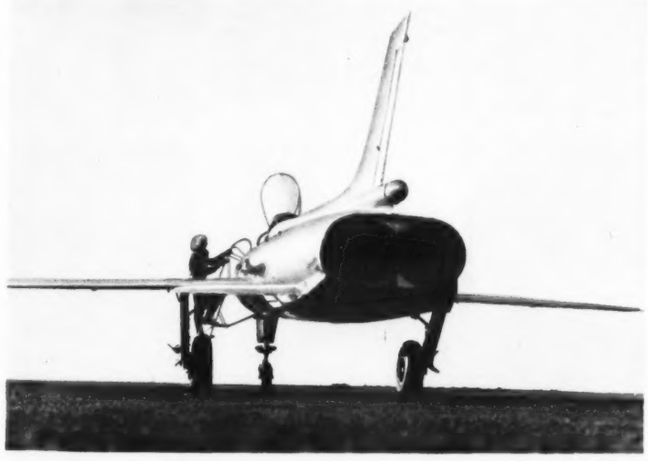
● The *de Havilland Gyron* turbojet is to be the powerplant for the Hawker private venture supersonic strike fighter.

● *Avro Shackleton T.4* is the designation of a navigation trainer version of the four-engine naval patrol aircraft developed for R.A.F. Coastal Command.

● The jet engines built by VEB Industriewerk Karl-Marx-Stadt (Chemnitz), East Germany, for installation in Prof. Baade's BB-152 four-jet commercial transport are at present undergoing bench tests. The engines have a thrust of 6,940 lbs.

● The *SNECMA-ATAR 9* will shortly begin flight tests in an *Armagnac* converted into a flying test bed.

Breguet 1100 light ground attack aircraft, fitted with two Turboméca *Gabizo* jets of 2,420 lbs. static thrust each. The aircraft is designed for high operational flexibility. For example, it can operate from hastily prepared fields, with runway lenghs of less than 1,000 yards.



Chief pilots Frank M. Briggs and Richard Vinal (L/R) discuss with Fisher extensive flight testing with Champions. Veterans of 22 years with Pan American World Airways, the two captains are responsible for all Miami test flights for the "World's Most Experienced Airline."

Another in a series on the care taken by leading airlines to maintain top flight efficiency—and why this care has led them to select CHAMPION SPARK PLUGS. Noted aviation authority reports on Pan American World Airways . . .

"World's Most Experienced Airline"

by **HERB FISHER**

international aviation authority, veteran test pilot, and author

HERB FISHER

Just Over the Horizon . . .

Crowning the gigantic Pan American World Airways Maintenance and Overhaul base at Miami International Airport—like a royal crest of honor over this gateway to Central and South America—are these brilliantly lighted words: "World's Most Experienced Airline."

No airline slogan has commanded more unqualified global respect. Since the maiden flight of its Jenny-type Fokker F-7 tri-motor "Clipper" 30 years ago, Pan American has distinguished itself with a singular history of world-wide aviation development and airline safety.

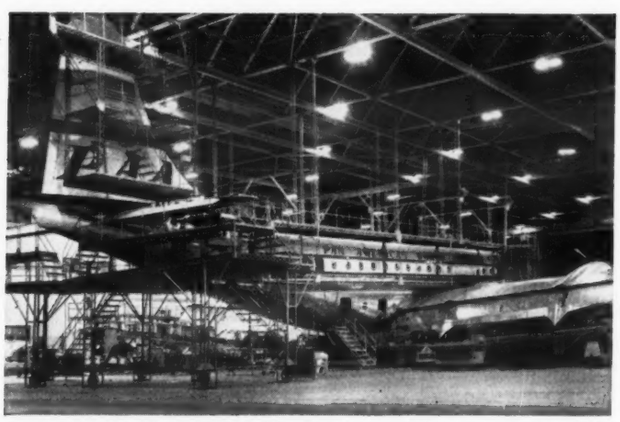
Pan American pioneered trans-oceanic routes to South America, Europe and the Orient. Its famous Clippers have flown more than 700,000,000 miles—equivalent to 28,000 trips around the globe. PAA has carried well over 10,000,000 commercial passengers to and from six continents and 82 countries and colonies over the Earth.

Pan American told me it has received more awards than any other airline—tangible testimony to an excellence of performance based on experience in operation and maintenance. In international aviation circles, Pan American has become synonymous with efficiency and safety experience.

Receiving a cordial invitation, I spent several days inside PAA's Miami Overhaul Base (MOB), delving into why Pan American maintains a top position in the air transport industry. This overhaul base occupies 50 acres, 30 under roof, and employs some 2,500 year-round workers. It's the largest airline overhaul plant in the world . . . home base for Pan American's headquartered Latin American Division fleet, serving Central and South America, as well as overhaul center for PAA's Atlantic Division, covering Europe, Africa and the Middle East.

Establishment of MOB in 1948 marked another historic first for Pan American: first time a mass-production, factory-method operation in airline aircraft maintenance had ever been tried. Now, with more than 10,000 engines alone having been overhauled there these past eight years, MOB is an airline industry model.

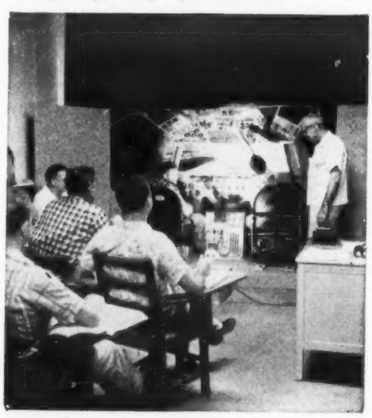
Each of Pan American's 135 multi-engine aircraft comes in biennially for complete disassembly—Boeing Super Stratocruisers, Douglas DC-4's, DC-6B's, DC-7B's, DC-7C's, Convairs. The whole ship is dismantled and reconditioned from wing panels to cabin carpeting. Engine parts, for example, are chemically and mechanically cleaned until not a vestige of dust or baked-on carbon remains. Parts are then minutely examined with the most modern inspection equipment to insure their soundness and suitability for reuse. Throughout reassembly stages, each unit is tested for operational perfection.



Like ships of sea, giant Clippers of Pan American, too, must come in for a "dry docking" to insure maximum public safety. They're completely disassembled and reconditioned. A special 75-ton dock of movable and stationary sections was designed by PAA to handle this double-deck "Strato" Clipper, largest commercial airliner in operation.

Self-explanatory are these safety reminders, which Fisher observed throughout the Miami Overhaul Base. Maximum safety efforts from the ground up – up to the stars – put teeth in the slogan, "World's Most Experienced Airline."

Veteran pilots and crew members get constant refresher courses to keep them at peak efficiency. They're required to spend many hours in this "flight simulator," a classroom cockpit duplicating flight conditions.



. . . But, in the Beginning . . .

"World's Most Experienced Airline". . .

a special report for Champion Spark Plug Company

A look at the immediate future with a nostalgic glimpse into the pioneer past is provided by these two Clippers, the pride of their respective eras. Representative of *Tomorrow's* Clipper is this Douglas DC-8 jet. Pan American's jet Clipper fleet—Boeing 707's and DC-8's—is scheduled for service in 1959 and will transport up to 150 passengers per plane at speeds around 600 mph. *Yesteryear's* Clipper, this Sikorsky S-40, was the first PAA plane to bear the now-famous "Clipper" title . . . also the world's first four-engine commercial seaplane. It was delivered to Pan American 26 years ago.

Finally, the completely reconditioned engine is tested on one of Pan American's giant engine test stands for multiple assurance of functional perfection.

Engine Overhaul at MOB occupies a seven-acre building, where up to 300 engines per month can be completely reconditioned. Ignition system overhaul is done in the Accessory Overhaul building, a structure almost as large as Engine Overhaul.

As a pilot, you're not long in the driver's seat behind an engine before you realize the heart of a powerplant is its ignition system. Having spent more than 12,000 hours aloft behind hundreds of engines, I was most anxious to inspect Pan American's Ignition Overhaul. Here, Pan American reconditions everything from magnetos to spark plugs.

The spark plug, of course, is the vital powerplant life-giver upon which all other plane parts are dependent to stay aloft and safely power millions of passengers millions of miles through all kinds of atmospheric conditions.

As I observed installation of spark plugs in the many types of overhauled engines, the very capable manager of MOB, Santos Ceyanes, explained: "We've used Champion Spark Plugs for years. Occasionally we test other plugs, but we always return to Champions. We fly Champions an average of 350 hours between removals. We've never found a better spark plug, and we've tested them all, extensively. Reliability and performance dictate Champions as our necessary choice. Long life, service and economy bolster those vital requisites of choice."

In selecting a spark plug for an aircraft engine, the engine manufacturer first runs exhaustive tests to determine what plug best meets heat-rating and other operational requirements of the engine, William W. McClintock, powerplant engineering superintendent, told me. Then, a limited quantity of the appropriate plug is released to the airline for flight evaluation. A history of the plug's characteristics—performance, reliability, gap erosion, total life, ease of reconditioning, etc.—is recorded throughout testing. Spark plug histories are carefully compared with those from tests of other spark plugs.

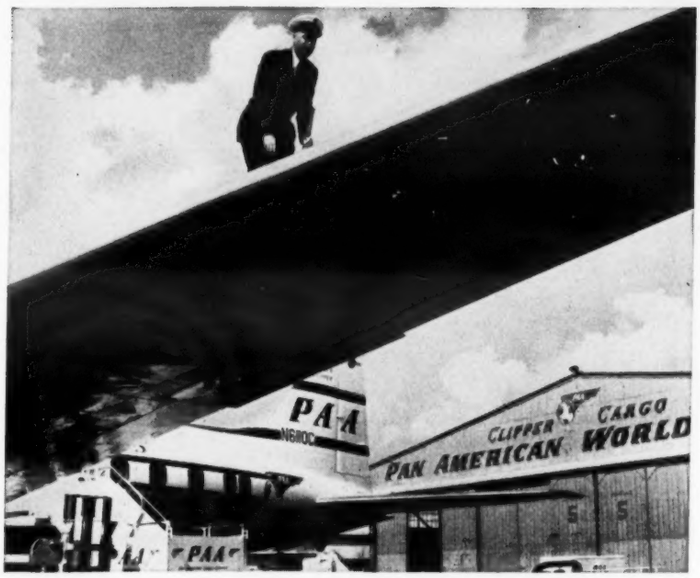
"Champions have surpassed other plugs in these tests since we began using Champions in 1943," Mr. McClintock said. "We find, for example, that Champions give us less lead fouling and electrode erosion while maintaining excellent ceramic stability. MOB-overhauled engines have accumulated millions of high-efficiency hours while using Champions."

As powerplant engineering installation supervisor, Morton H. Woolf heads the engineering staff charged with evaluating ignition system test results. With cold objectivity, then, he selects Champions.

Handy with a tape recorder, Fisher talks to Santos Ceyanes, manager of the Pan American Miami Overhaul Base, about the magnitude of overhaul and maintenance that has contributed to PAA's well-earned safety slogan, "World's Most Experienced Airline."

Douglas A. Shropshire (L), Champion aviation representative, gives technical assistance to (L/R) G. F. Sheppard, an Electronics general foreman, and Clyde Walkup, assistant Ignition Overhaul foreman.

When engines have been reconditioned right down to the last nut, bolt and spark plug, they're reassembled and tested in this Engine Test Cell.



An extra safety precaution is taken by Flight Engineer W. F. Kellegrew, a 15-year Pan American veteran who takes nothing for granted: he double-checks his wing-tank fuel supply preparatory to taking off for Latin America. Airborne, he feels secure behind engines equipped with Champion Spark Plugs.

According to L. R. Sayre, a 27-year Pan American veteran and assistant service superintendent, the calculated decision to use Champions has been remade every year since the original decision 14 years ago.

Henry Mossberger, powerplant engineer directly responsible for ignition engineering problems, told me how the Champion Spark Plug Company has "given every cooperation and assistance" in extending the spark plug lifetime sufficiently beyond that of other plugs, providing the ideal combination of plug economy and reliable performance. "After hours of exhaustive extended-life service tests, we find the die-hard Champion without equal."

At this point, I had been thoroughly checked out in the operation of PAA's massive Miami Overhaul Base by an efficient staff. I'd seen the great Clippers of the "World's Most Experienced Airline" disassembled and reconditioned right down to the last spark plug.

And, in the end, I know—being an old test pilot myself—that it is the pilot himself who has the real throttle-hand appreciation of the engine. Capt. Richard Vinal, assistant chief pilot, technical, and a 22-year PAA veteran, confirmed my feeling: "I run flight tests, demonstration flights and performance checks. In these, we've used Champions for many years. They're unequaled. Herb, I use them in my car—and even in my lawn mower."

Capt. Frank M. Briggs, Latin American Division chief pilot, added: "In my 22 years with Pan American, I've logged more than 16,000 hours—mostly on Champions. Everyone knows the high safety record Pan American has, and, quite naturally, we've guaranteed this safety experience to the public with use of the best possible parts and equipment. Herb, I feel very strongly about the success we've had with Champions."

Over-all, the importance of a vendor's cooperation, and Champion's in particular, was summed up by R. D. Charles, MOB assistant superintendent of overhaul and a 27-year PAA veteran: "Champion's close cooperation and efforts to constantly improve the product—new insulators, for example, and lighter type construction, incorporating the best materials—point up the fact that we are using one of the finest products in the field."

Wherever I went and with whomever I talked there at MOB, the reasons for using Champions became increasingly obvious. Service, reliability, long life and economy seem to sum up Pan American's reasons for unanimous Champion preference.

—by HERBERT O. FISHER

Discussing engineering tests are (L/R) William W. McClintock, Powerplant Engineering superintendent; M. H. Woolf, Powerplant Installation Engineering supervisor; Fisher; and H. I. Mossberger, Powerplant engineer.

"Champion's close cooperation and efforts to constantly improve their product point up the fact that we're receiving the finest spark plug in the field," R. D. Charles, assistant Overhaul superintendent and a 27-year PAA veteran, tells Fisher.

A. S. Galbraith, Division Supply Manager, LAD-PAA: "Cost, quality and service life determine product selection. All three factors apply to Champions."

CHAMPION SPARK PLUG COMPANY: ENGLAND, UNITED STATES, CANADA, AUSTRALIA, IRELAND, FRANCE

We "IATANS" are the First World Citizens

by W. Deswarte,

General Manager, Sabena, Brussels

Sabena's General Manager writes: "I am sending you, on the off-chance, the text of a brief article—or rather a piece of fancy. Do with it whatever you like."

Interavia *is happy to be able to pass on to its readers throughout the world this confession of faith by an air transport expert and citizen of the world.*

Editors.

"There are no more distances!"

"Our economy spans the world."

"National barriers have been broken down."

These and other aphorisms are heard every day. They are either outright deceptions or, at best, ahead of their time. To realize this, we members of the international airlines have only to compare ourselves with our contemporaries.

The vast majority of men still live within a *national framework*, under *national* laws, tied to the needs of the *national economy*, knowing only their own *national language* and using only *national currency*.

When the tourist, the businessman, the artist or the politician travel abroad, this is for him only a limited experience, a simple interlude in a life entirely governed by national factors.

Yet when he travels he is at liberty—to suit his convenience or his fancy—to take a Swissair aircraft from Tokyo to Barcelona, to embark on Air France in Montevideo in order to fly to Cairo, to take a Belgian aircraft at Johannesburg for a trip to New York, or a Pan American aircraft from Karachi to London.

The 76 airlines grouped under the International Air Transport Association have, with the latter's aid, covered the world with a network of air services which are to a large extent freed of national restrictions. Each of us bears responsibility for certain sectors of this network, sectors which in many cases are far from our centre of operations.

Thus, when I think of our services from Milan, I know that seven other airlines are also concerned. For New York there are eleven, six for Brussels, two for Leopoldville, five for Stockholm, four for Khartoum, and so on. Each of these services and the problems arising from them will be dealt with by each of us not according to our own national rules and regulations, but according to the 300 I.A.T.A. resolutions, which form a universal code regulating our airlines' relations with travel agencies, their responsibilities to their passengers and even the size of the tickets issued, whether it be in San Francisco, Vienna or Tel Aviv.

When the problems arising fall outside the contractual domain and have to be settled by governments, we find that the operating conditions laid down by our various countries are all based on the recommendations of the International Civil Aviation Organization, and that the procedures to be followed for a landing at Damascus, Frankfurt or Caracas are practically identical.

Admittedly, each of our 76 airlines sells its tickets, at uniform rates, in more than 90 different currencies throughout the world, but more than 60 of them have freed themselves of all problems of conversion or partial settlements between countries by joining the I.A.T.A. Clearing House in London, which offsets payments to the individual airlines and settles the balance payable to each in its own currency.

Civil aviation has abandoned national prejudices and adopted a single language, English, which some airlines even use for their internal reports.

As regards legal jurisdiction, we are, fortunately, rarely called before our own national tribunals, but we do from time to time have to answer for infractions of the numerous I.A.T.A. regulations. We then appear before an international tribunal against which there is no appeal, and which is also organized by our international community.

Before the advent of air transport, distances expressed in miles or kilometres gave an adequate idea of the effort required for a journey. In the age of air travel we more often hear it said that Brussels is 13 hours from New York. In fact, the aircraft has so far cut down travel time that nobody is now prevented by lack of time from visiting any point on the globe. No two points are now separated by more than 40 hours. The real obstacle to widespread travel today is its cost, and what we should really say is "Brussels is 310 dollars from New York." This is why air transport's greatest efforts must be directed at reducing fares.

For members of the I.A.T.A. airlines, who travel free on business, the whole world is accessible to them at all times. And most of them do not hesitate to take advantage of this fact.

In the course of a single year we find the commercial experts holding their annual meeting at Miami, preceded by preparatory talks in London and New York. Agency problems are discussed in Paris and cargo rates in Rome. Our medical experts hold their congress at Palma de Mallorca or meet in Washington for a symposium on jet aircraft. The same applies to our legal experts and our communications experts.

As for our engineers, they keep their eyes constantly glued on the Pacific Coast between Seattle and San Diego and rush off to discuss even the smallest technical problems with the big aircraft manufacturers established there.

Finally, on the "top management" level, everybody meets, at least once a year, at the I.A.T.A. General Meeting, which since 1945 has been held successively at Montreal, Cairo, Montreal, Brussels, The Hague, San Francisco, London, Geneva, Montreal, Paris, New York and Edinburgh.

Thus, the heads, experts and engineers of the 76 I.A.T.A. member airlines provide a foretaste, on both the material and the intellectual level, of a world at last unified.

While those who are working to "make Europe" enjoy our sympathy, they also arouse our fears that a movement that is already worldwide might be reduced to the scale of a single continent.

Does this mean that we are "denationalized"? Definitely not; but we have had the good fortune of taking a step which the rest of humanity will have to follow—or perish. We remain attached to our countries as others love their native towns; we love the world as others love their country.

Aviation Traders
ATL. 90 Accountant

Prototype of the ATL.90 *Accountant* on its way into Aviation Traders' flight hangar at Southend-on-Sea... minus propellers or tail fairing.

Designers in many countries have for years been working to arrive at a replacement for the Douglas DC-3 which, if it is to win a place on the world market, must meet the special requirements of many different airlines. The formulæ already proposed are very varied : two or four engines, with piston engines or propeller turbines, high wing or low wing, etc. A relative newcomer to the contest is *Aviation Traders (Engineering) Limited*, with its twin-turboprop *Accountant*, the prototype of which was due for its first flight as these lines went to press.

From the outset the designers of this aircraft had three basic requirements in mind :

1. The projected short-range aircraft must meet both American C.A.A. and British civil airworthiness requirements.

2. It must be substantially superior to the DC-3 as regards performance and transport capacity, without sacrificing the older aircraft's good take-off and landing qualities.

3. Finally, it must be sufficiently adaptable to enable the same airframe to be used, without major structural alterations, as passenger airliner, freight transport or luxury executive aircraft. A preparatory market survey carried out by Aviation Traders clearly revealed that there is lively interest in executive aircraft of the *Accountant* class, in particular in Canada and the United States.

*

What has the Accountant to offer in the contest for the DC-3 replacement ? — In the first place a rugged airframe which is cheap to produce and whose weight is only 28 % of the total take-off weight. Secondly, reliable, long-life propeller turbines and propellers (operating time between overhauls roughly 1,200 hours in both cases), which have been proven over years of operation in almost two hundred Vickers *Viscount* transports. Not only the actual engines, but also the accessories, mountings, etc. are similar to those in the *Viscount*, so that operators can rely on the Rolls-Royce world-wide service organization for spares.

When it comes to fuel costs in comparison with the piston-engine DC-3, the following figures underline the *Accountant's* operating advantages : assuming the price of petrol to be 18 pence par gallon, and the price of kerosene to be 10.75 pence per gallon, the cost of filling up all tanks in both types would be roughly the same, namely £50. Whereas, however, the DC-3 flies 1,040 nautical miles in 6.7 hours on full tanks, the *Accountant* covers a distance of 1,570 nautical miles in 6.7 hours, and a total distance of 1,790 nautical miles on full tanks, i.e., *for the same fuel costs*, and under IFR conditions.

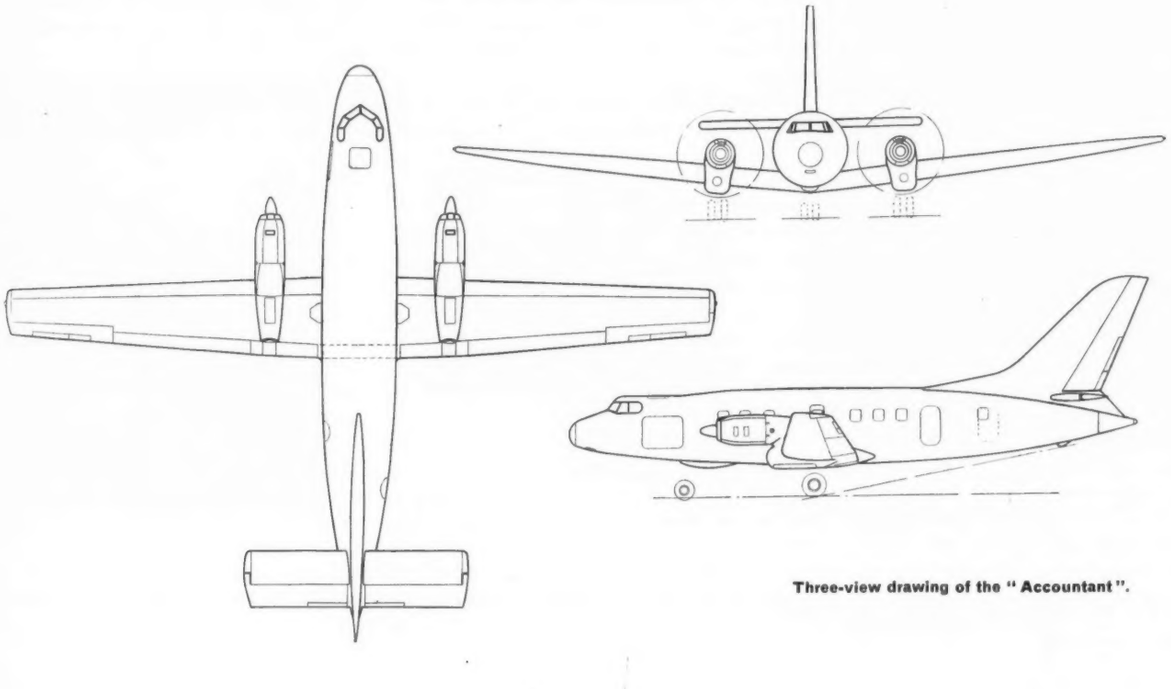
Finally, it is planned to hand over three pre-production models of the *Accountant*, immediately they are completed, to Air Charter Ltd., an associate company of Aviation Traders, for operational testing, so that concrete operating experience will be available by the time the first production models are delivered (about 1959).

*

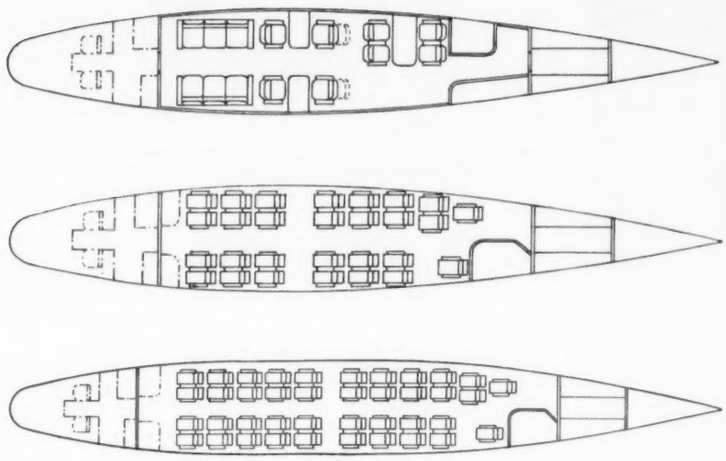
The *Accountant's* airframe has been designed for " growth " from the beginning, particularly in the direction of higher power for the engines and hence higher cruising speeds. The design of the pressure cabin was originally based on a mean cruising altitude of roughly 30,000 ft. at 6.5 p.s.i. However, in order to be able to maintain a cabin pressure equivalent to 8,000 ft. without exceeding the maximum differential pressure of 5.5. p.s.i. recommended by the C.A.R., the manufacturers decided to reduce the mean cruising altitude to 25,000 ft. Freight and special missions without passengers, however, can be flown, with reduced cabin pressure, at altitudes of up to 30,000 ft. In addition, the airframe is designed for a manœuvring load factor of 2.73 and a maximum indicated air speed of 274 knots (diving speed).

Brief description of aircraft structure

The *five-part wing unit* is bolted together in the centre of the fuselage, outboard of the engines and inboard of the ailerons (at about 60 % of the half span). The front spar web (at 19 % of the chord) and the rear spar web (at 65 %), together with the top and bottom stringer skin panels, form a box spar, in which the only major discontinuity, apart



Three-view drawing of the " Accountant ".



Cabin layout for the 8/14-seat executive version (top), the 28-seat standard version (centre) and the 40-seat tourist version (bottom).

Powerplant

Two Rolls-Royce *Dart RDa.6* propeller turbines	
Take-off power per engine	1,730 t.e.h.p.
Max. fuel capacity	1,280 Imp. gals.

Design performance

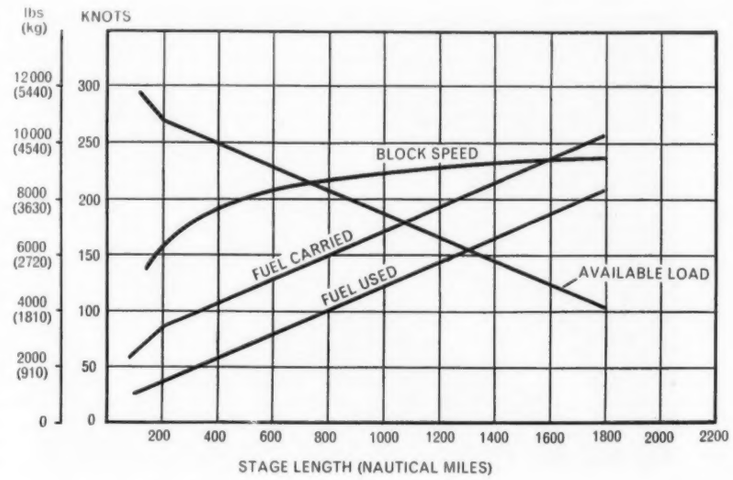
Mean cruising speed (13,600 r.p.m.)	256 knots
Stalling speed, 26,000 lbs., flaps down	69 knots
Sea level rate of climb (I.S.A.) two engines	1,500 ft./min.
Sea level rate of climb (I.S.A.) one engine	500 ft./min.
Service ceiling	33,000 ft.
Service ceiling, one engine	15,000 ft.
Time to 25,000 ft.	27.6 mins.
Sea level take-off balanced field length at 28,500 lbs. (I.S.A.)	3,220 ft.
Sea level take-off balanced field length at 28,500 lbs. (I.S.A. + 15°)	3,400 ft.
5,000 ft. take-off balanced field length at 28,500 lbs. (I.S.A.)	4,000 ft.
5,000 ft. take-off balanced field length at 28,500 lbs. (I.S.A. + 15°)	4,300 ft.
I.F.R. stage with 28 passengers and luggage	650 nautical miles
I.F.R. maximum stage	1,790 nautical miles

Weights

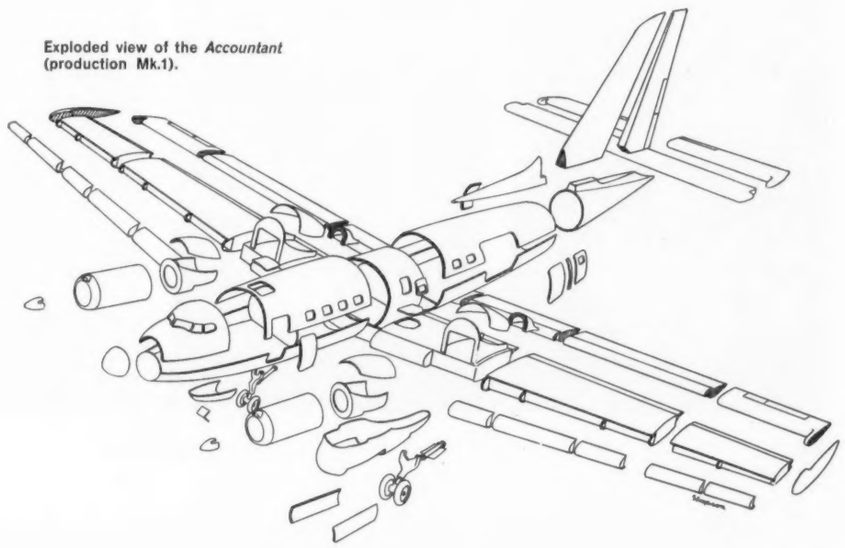
Mainplanes	3,129 lbs.
Fuselage	2,910 lbs.
Tail unit	670 lbs.
Landing gear	981 lbs.
Nacelles	250 lbs.
Total structure	7,940 lbs.
Engines — dry	2,364 lbs.
Mountings, cowlings, intakes, etc.	500 lbs.
Exhausts, jet pipes, accessories	220 lbs.
Propellers (incl. spinners, controls, etc.)	710 lbs.
Total power plant	3,794 lbs.
Fuel system	136 lbs.
Water/methanol system	35 lbs.
Residual fuel and oil	116 lbs.
Total fuel and oil supply	287 lbs.
Hydraulics	404 lbs.
Pneumatics	35 lbs.
Electrics	970 lbs.
Flying controls	280 lbs.
Accessory gear boxes	130 lbs.
Instruments and auto controls	422 lbs.
Anti-icing system — dry	302 lbs.
Fire precautions	80 lbs.
Air conditioning	360 lbs.
Flight crew furnishings	106 lbs.
Total airframe equipment (less radio, radar and cabin equipment)	3,089 lbs.
Weight empty	15,110 lbs.
Initial available load + fuel (incl. max. internal fuel weight 10,240 lbs.)	13,390 lbs.
Initial take-off weight	28,500 lbs.
Max. landing weight	27,100 lbs.
Zero fuel weight	26,500 lbs.

Dimensions

Span	82 ft. 6 ins.
Length	62 ft. 1 in.
Height	25 ft. 3½ ins.
Wing area	632 sq. ft.
Aspect ratio	10.77
Wheel track	21 ft. 8.3 ins.
Wheel base	12 ft. 8 ins.



Available load*, fuel carried, fuel used and block speed plotted against stage length. The diagram is based on the following data: initial take-off weight 28,500 lbs., operating altitude 25,000 ft., climbing and cruising r.p.m. 13,600, descent at 230 knots true air speed at 1,000 ft./min.

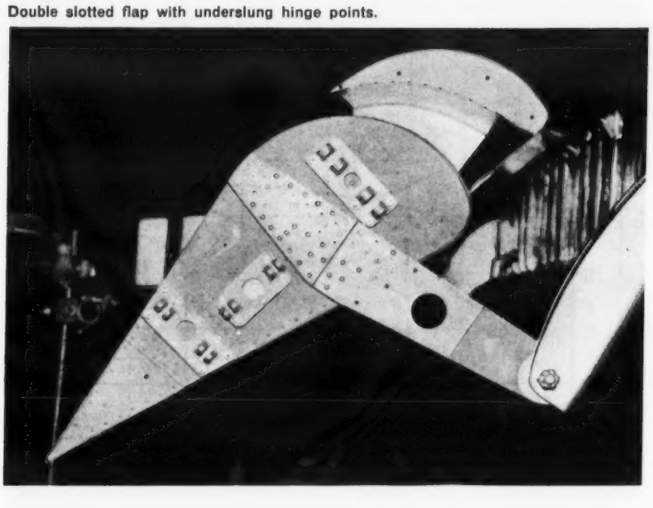


Exploded view of the *Accountant* (production Mk.1).

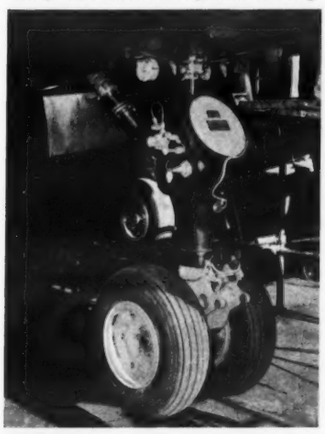
* Available load is defined as that load which is available for radio, furnishings, soundproofing, operators' service items, crew and payload.

Pilot's cockpit : controls and instruments for the left-hand pilot's seat.

Double slotted flap with underslung hinge points.



Dowty nose wheel with hydraulic steering motor (left) and main undercarriage.



from the multi-bolted joints, occurs in the top surface at the fuselage side. Here the loads carried by the stringer skin panel are diffused into two compression booms across the fuselage, while the bottom surface continues uninterrupted to the joint at the fuselage centre-line. In this way the cut-out in the fuselage to accommodate the wing is reduced to two easily reinforced narrow slots. Thus inter-action between the fuselage, which is stressed by the cabin pressure loads, and the wing is kept to a minimum. — The wing trailing edge carries double slotted flaps in five parts, which reduce stalling speed to roughly 70 knots. At take-off, the flaps act as single slotted flaps, so that drag is much less than during landing approach.

The *three-part fuselage* is of monocoque construction, stiffened by close-set bulkheads. Thanks to its cigar shape, the stress level is kept low throughout. In regions of complicated stress conditions, e.g., the windscreen posts, the fail-safe principle, under which failures in one structural component are halted by the next component, is used to raise operational safety.

Tail unit : Single-piece horizontal tailplane of rectangular planform with two-part elevator ; one-piece fin with one-piece rudder ; conventional construction, double-walled leading edge for hot-air de-icing.

Controls : Main control surfaces operated without power boost via light metal tubes ; trim tabs operated by cable (up to control surface) and by light metal tubes (to the tabs themselves).

Undercarriage : Short-legged hydraulically operated nose wheel and main units (Dowty) with double low-pressure tyres, disc brakes and anti-skid device (Goodyear). Emergency operation hydraulic, by means of a storage accumulator.

Electrical system : 28V D.C. supply from two 6 kW generators driven from the engine accessory gearboxes ; four 24V 25 AH batteries which can be used for engine starting if required ; three 115V, 400 c.p.s. rotary inverters to provide power for flight instruments, autopilot and VOR/ILS ; two 7.5 kVA three-phase generators to supply the 208V de-icing system for engine intakes, propellers and propeller hubs.

Radio : The final decision as regards radio equipment will, of course, be made by individual customers. The prototype carries a HF transmitter-receiver, dual VHF transmitter-receiver, ADF receiver, ILS/VOR equipment and crew intercommunication. In all versions of the *Accountant* the radio station will be on the starboard side forward, between the cockpit and the main fuselage.

*

As already indicated, initial plans cover the following versions :

1. Standard version for 28 passengers ;

2. Executive version for about 12 passengers, with reduced payload and bigger fuel reserves ;

3. Freight version, with large freight door.

In addition a mixed passenger/freight version with movable fuselage compartment partitions, as well as special versions for aerial survey, aerial prospecting, etc. are also under consideration. The manufacturers are thinking of a Mark 2 model for 40 passengers, which would carry a greater payload rather than extra fuel.

Due to the method of fuselage construction the 40-seat version can be put in hand in the early phase of development. Meanwhile, this original design, even in its present form, promises to be a serious contestant for the DC-3 succession.

Inside the *Accountant*'s fuselage, looking towards the cockpit : the electrical distribution box can be seen on the starboard side just rear of the cockpit.

The White Paper on Defence
A British View

By Derek Wood, London Editor

On April 4, Her Majesty's Stationery Office issued a small drab 10-page leaflet entitled " Defence. Outline of Future Policy ". This seemingly innocuous annual document, weeks late and frequently revised, burst like a miniature atomic bomb on the Services, the Public, the industry and other N.A.T.O. countries.

For the first time Britain swept the whole defence deck clear and threw old ideas headlong overboard. With short perfunctory sentences the axe fell upon manpower, conventional weapons, and by 1962 the three Services could see their total strength reduced to less than the size of the present army.

The physical reductions in troops, fighters, light bombers, etc. in Europe would seem on the surface to represent a lessening of Britain's ability to take her share of N.A.T.O. obligations.

In fact in the May *Interavia* Review, M. Pierre Gallois went so far as to say that " Such a defence system, if carried to its logical conclusion, would be of solely national and not collective value ".

Such an assertion does not, however, stand up to any searching examination. For years one of the greatest forces behind N.A.T.O. has been the U.S. Strategic Air Command with a " round the clock " readiness force of first B-36s, and later B-47s and B-52s with atomic and hydrogen weapons. While in essence a purely national asset, the S.A.C. has undoubtedly stopped Eastern manœuvres and local aggression from passing the " flash point " of a nuclear war through fear of reprisal and world devastation.

Until recently there have been only two major powers in the atomic arms race, the United States and Soviet Russia ; i.e., two powers with nuclear weapons and the means to deliver them. Now there is a third, the United Kingdom.

The increase in overall firepower for N.A.T.O. arising from the availability of British guided weapons and nuclear warheads will be enormous. For so-called " local " conflicts the possession of the mobile ground-air and air-air missiles and the stand-off bomb, even with conventional warheads, will be a major factor to be reckoned with.

One cardinal point M. Gallois has overlooked. A nation that does not possess a workable hydrogen bomb, its own store of atomic bombs and a long-term production and development programme for vehicles to carry them has no choice as to whether or not it shall adopt a " deterrent strategy ". It is extremely easy to criticize from the sidelines when in the happy position of only being able to pursue one policy through lack of an alternative.

Following the post-war run-down of the Services in Britain, the lack of investment in research and the subsequent troubles and delays in military aircraft, a very great deal of money and effort has been put into military aviation and nuclear weapons. All this is beginning to bear fruit, and the Defence White Paper is an attempt to exploit the undoubted progress that has been made, and at the same time reduce the crippling annual British defence bill which the island taxpayers have been footing, to a figure far in excess of their continental colleagues.

That the White Paper is not just a shot in the dark is borne out by the spate of announcements on new weapon production and evolution. Within the last two months it has been announced that two ground-air weapons—one mobile by English Electric and one fixed-base by Bristol (the *Bloodhound*)—are in production, and the advanced infra-red heat homing de Havilland *Firestreak* air-air weapon is on the factory line and shortly due to complete R.A.F. acceptance trials. Meanwhile the R.A.F. is gaining the first European operational air-air weapon experience with production batches of the Fairey *Fireflash*.

In addition the Royal Navy has commissioned its first escort ship which will have the Armstrong Whitworth *Sea Slug* ground-air missile, and A. V. Roe are well advanced with the supersonic guided stand-off rocket bomb. This when fitted on the " V " bombers (there will be hundreds not tens M. Gallois !) will lengthen their life by several years and will obviate the necessity for building a large supersonic bomber. From Australia comes news of the test programme being put in hand for the British I.R.B.M., rumoured to be by de Havilland.

Finally, the series of tests in the Pacific with the British hydrogen bomb will show that the warheads will be, for good or ill, a reality and not just a dream. Already atomic bombs are available in the United Kingdom and 2nd T.A.F. for the *Canberras* and the " V " bombers, and the Air Ministry makes no bones about the fact that the defensive weapons will ultimately use nuclear warheads as standard.

This whole picture is completely different from that of a year ago when no guided weapons were yet in production, the P.1B fighter had not flown, and the nuclear tests were not imminent.

The ultimate development of British I.R.B.M.s and I.C.B.M.s and the fully automatic defence system working via radar and computers will take years. Nevertheless, Britain is the first country in the West outside the United States to accept its economic limitations, fix its course for the next decade and be on the way to achieving the first phase of it.

The Aircraft Industry

While a spectacular change in aircraft procurement in Britain has long been forecast, and requirements for new combat aircraft have dwindled away during the past two years, some firms seem to have been taken by surprise by the bluntness of the Defence White Paper's statements. Its long-term effects are unlikely, however, to be as serious as some would maintain.

The decision to forgo fighters other than the P.1B and to dispense with the supersonic Mach 2.5 long-range bomber may in the first instance seem disastrous in view of the number of firms still devoted solely to military production.

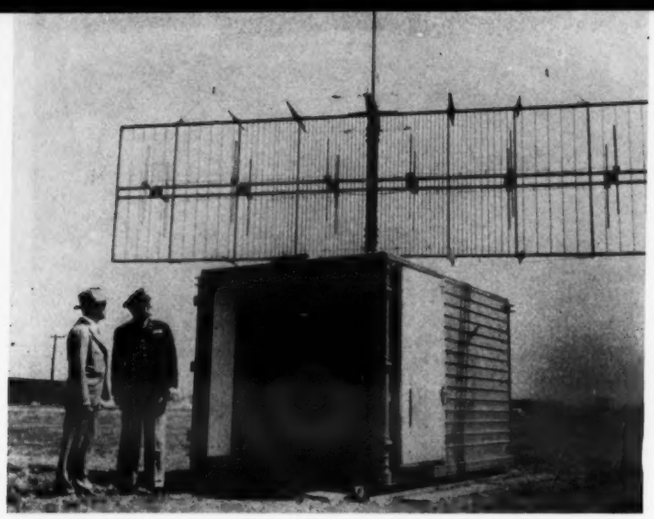
Missile production may fill part of the gap and there are still prospects of more combat aircraft contracts on a limited scale over the next few years. A maritime reconnaissance machine will be needed to replace the *Shackleton*, and a long-range strike-fighter-bomber of new conception will very probably replace the ubiquitous *Canberra*. While the Defence Statement categorically says that work on fighter projects to succeed the P.1 " will stop ", it is still felt in Service and industry circles that, when enough operational experience has been amassed on ground-air weapons and on the P.1, a requirement may well be found for a specialized interceptor beyond the Mach-2 stage, if only to cope with long-range jamming aircraft. Meanwhile the Navy has been shown that practically its only worthwhile asset is the Fleet Air Arm, and ordering of combat types for carrier-borne use will continue for a very long time.

On an overall basis, the aircraft industry is in a much better position financially and organization-wise to change its course than just after World War II. An example of this was immediately apparent in the purchase by A.V. Roe Canada Ltd. of 150,000 Algoma Steel Corporation shares and the offer by the Hawker Siddeley Group (its parent company) to acquire the whole of the £22 million issued capital of the Brush Group of electrical companies.

Diversification will only solve part of the present problems of providing work for the shops as present warplane contracts run down. The answer will have to lie in transports, with some firms losing a good deal of their identity, taking in washing from associated companies.

Such firms as Bristols and Vickers are deeply immersed in the civil field and they have amassed considerable experience in the hardest school. Those that wish to follow will have to take the same hard road, and there are signs that they have started out upon it.

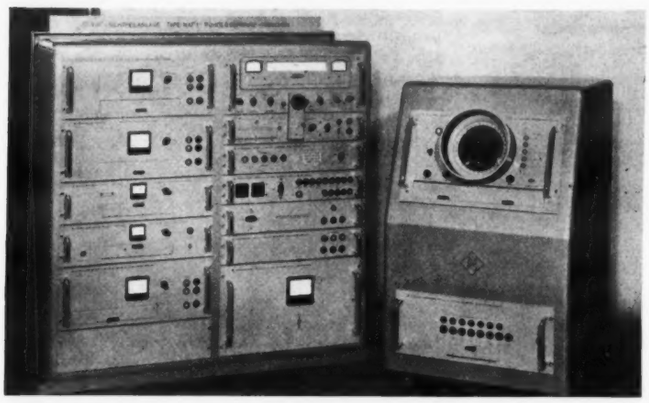
Two major points affecting the industry's prospects have yet to be cleared up. The first is the future position and strength of Transport Command and the Independent Operators, and secondly the scale of future research and development contracts. There is a fear, not allayed by recent Government announcements, that research funds will be cut. This would seriously affect the industry's ability to produce new transports and turbines.



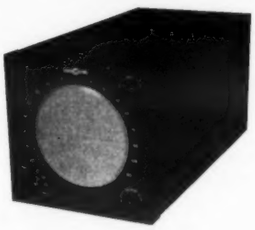
Equipment Round-Up

● **Air Associates Inc.,** Teterboro, N.J., has developed, under contract to the Army Signal Corps, a VHF/UHF " Talking Beacon ", which gives pilots their correct compass heading every 15 seconds, via their normal receiver. At normal altitudes, the beacon can be received up to 50 miles away. The experimental equipment shown here consists of three VHF and three UHF transmitters, which operate in the frequency range of 118-136 Mc/s (VHF) or 236-272 Mc/s and 354-400 Mc/s (UHF) and are stabilized by a common crystal. Mounted on the vertical antenna mast, which rotates at 2 r.p.m., are three separate antennæ, two of them directional (back-to-back) to transmit the voice signals, and the third with figure-of-eight radiation pattern to broadcast a continuous note and the station identification. A pilot flying between two beams will pick up both and can judge his proximity to each within 3° by the relative strength of their reception.

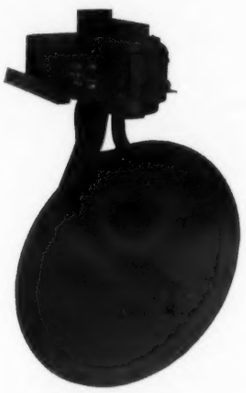
● **Rohde & Schwarz,** Munich: An automatic VHF D/F system for the 100-156 Mc/s frequency band, which displays on the scope of a cathode ray tube the bearing of any aircraft (in the form of a radial beam) transmitting a modulated or unmodulated radio signal, has been submitted to extensive trials and is now being introduced at German commercial airports. — The installation consists of an automatic, unmanned D/F equipment, generally set up on the airport's approach track, and a remote-operated indicator in the control tower. Two basic types are provided, to meet differing operating requirements: 1. system with ten-channel receiver and remote setting of the crystal-controlled frequency channels on the indicator (see picture); 2. system with two to ten pre-tuned receivers, in which case each of the receivers can be switched to any of the indicators. Bearing accuracy in both cases ±2°.



Cockpit control



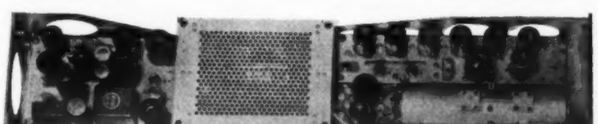
Indicator



Antenna group

● **Collins Radio Company:** WP-101 airborne weather radar, which operates on 5,400 Mc/s, consists of the 374A-1 transmitter-receiver, the 776C-1,-2 synchronizer, the 537F-1,-3 antenna rotating at 15 r.p.m., a 561G-1 cockpit control and 493A-1 indicator. The system presents a weather map of frontal and local weather conditions in the air space within a 150-mile radius and approximately 240° around the aircraft's nose. Ranges are 20, 50 and 150 miles. — Other features: Iso Echo circuit for sharp definition of turbulent areas; antenna reflector tilt +10° to —15°; antenna stabilized within ±35°; beam width 4.5°; weight of entire airborne installation roughly 120 lbs.

● **Collins Radio Company:** The Collins 621A-1 automatic interrogator/transponder facilitates Air Traffic Control's task of identifying and tracking aircraft and also enables the pilot to transmit important information to the ground station. The aircraft receives a pair of spaced pulses on 1,030 Mc/s and replies with a group of 2 to 8 accurately spaced code pulses and one identification pulse on a frequency of 1,090 Mc/s. The latter can, if required, be displayed on the surveillance radar scope. A total of 64 different coded replies can be selected by the pilot, who can thus pass all kinds of information (route messages, airport of destination, etc.) through to Air Traffic Control.



● **Canadian Aviation Electronics Ltd.,** St. Laurent, Quebec: Working in conjunction with the Royal Canadian Air Force and the Department of Defence Production, CAE has developed a Flight and Weapons Systems Simulator for the CF-100 all-weather fighter. The complete equipment consists of an exact replica of the CF-100 cockpit, an instructors' console and a number of computers, and can be used for three different training purposes: 1. transition and familiarization training for the CF-100; 2. training in emergencies; 3. tactical training in interception techniques. Including the cost of development, each unit runs into roughly 1½ times the cost of a CF-100 aircraft, i.e., more than $1,000,000. So far a prototype and eleven production models have been ordered.

Picture shows C. D. Howe, Canadian Minister for Defence Production (centre, above the pilot), and K. R. Patrick, President and Managing Director of Canadian Aviation Electronics.

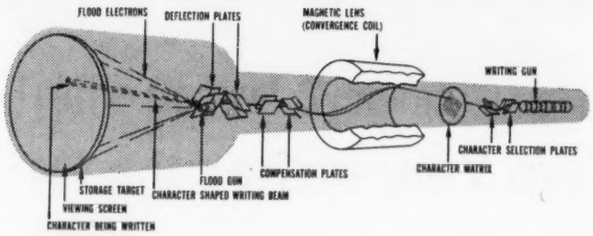
● **Hughes Aircraft Company** is marketing a series of new direct-display storage tubes, which work on the principle of conventional cathode ray tubes, but also use a flood gun and a dielectric mesh to retain any oscillograph or radar picture for at least a minute. To meet different applications Hughes has designed three different basic types of tube:

1. **Tonotron,** with large scope to present weather radar or plan position indicator information, viewing all kinds of television picture (instrument readings, traffic pattern transmissions, etc.).

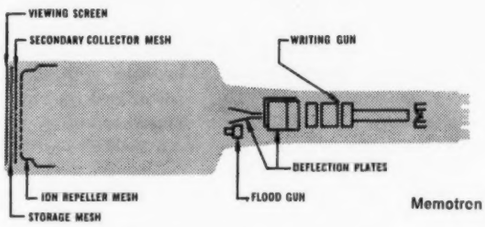
2. **Typotron,** for display of decoded results from digital computers (25,000 characters/second), of computed radar-tracking information or monitoring analogue-to-digital conversion equipment, etc.

3. **Memotron,** for the display of oscillograph pictures (in particular for the purpose of comparing wave forms), plotting families of curves, viewing transients from shock or vibration tests and ballistics or missile tests, etc.

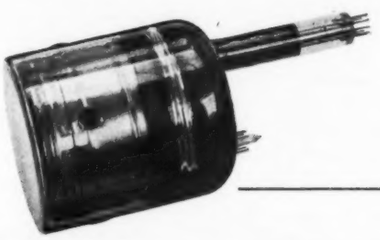
Fundamentally, all three tubes work on the same principle: the electrons emitted by a writing gun, on striking the storage mesh behind the viewing screen, liberate secondary electrons which charge the storage mesh in the written areas. Behind the storage mesh is a secondary collector mesh which attracts the secondary electrons. If the flood gun now sends further electrons towards the tube face, the storage mesh acts as a control grid, regulating the quantity of flood electrons striking the screen. A high positive charge corresponds to a bright area. The display can be erased almost instantaneously by applying a positive potential. — Unlike the Tonotron and the Memotron, the Typotron has a number of additional components between the writing gun and the direction plates on the one hand and between the screen and the storage mesh on the other: character matrix, magnetic lens, and extra compensation and direction plates.



Typotron



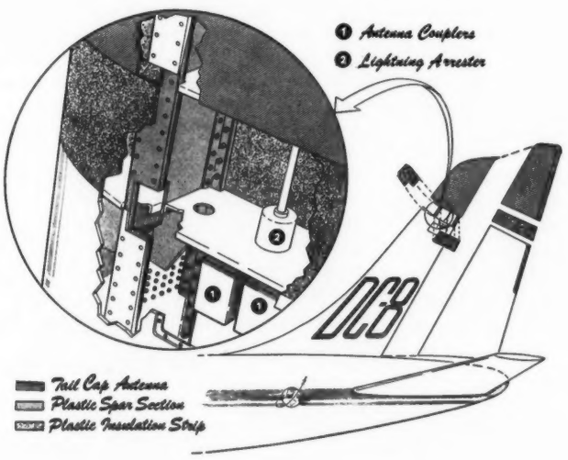
Memotron



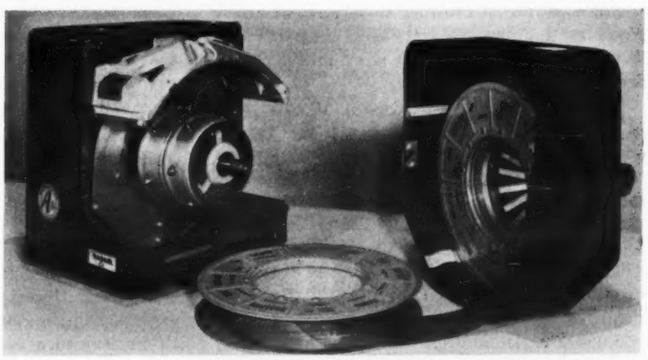
Tonotron

● **Packard-Bell Electronics Corporation,** Los Angeles: " Dual Pultrator " is the name of this pulse generator which can be used to simulate radar returns from multiple targets, video circuitry of beacon systems and unsynchronized beacons replies for traffic and interference studies. It does the work of 20 single-pulse generators in cascade and produces two trains of ten pulses with a pulse-width range of 0.3 to 0.6 microseconds and a spacing of 2 to 4 microseconds. By means of selector switches any of the pulses generated by the Dual Pultrator can be omitted or added to the trains, so as to produce a wide variety of pulse combinations.

● **Douglas Aircraft Company, Inc.;** After several years of research, Douglas has decided to equip the DC-8 with a tail-cap antenna for HF communications. This type of antenna has already been used successfully on various military aircraft and offers the following advantages over conventional wire, probe or flush types: no additional aerodynamic drag, better radiation characteristics, lower vulnerability to lightning, greater efficiency. The antenna shown here consists merely of the dielectrically isolated tip of the vertical tail plus two couplers and matching members (1) and a lightning arrester (2). Epoxy-fibreglass is used for insulation purposes.



● **North American Aviation Inc., Autonetics Division,** produces an airborne magnetic tape recorder which not only supervises the functioning of electronic fire control systems, but also records the pilot's most important operations. Known as **NADAR,** it automatically goes into operation when the fire control radar detects a target. — Left, the equipment housing with drive motor, tape holder, magnetic recording head and various electronic control elements; right, the tape magazine. — Some 850 F-86D **Sabre** jet fighters have been fitted with NADAR, as well as a large number of F-89H, F-94C and F-102A fighters. So far more than 3,000 NADAR equipments and some 150 playback systems have been delivered.



Two Years after the Restoration of Air Sovereignty

by Wolf Eberhard, *Interavia's* Bonn Correspondent

When German aviation got the green light in May 1955, it was widely expected that a well-planned, highly ramified aviation programme would get under way immediately in the West German Federal Republic. After all there were reasons enough for thinking so.

Had not the Lufthansa, after years of preparation, already begun experimental operations—a whole month, in fact, before Germany had regained her sovereignty in the air ? Did not the Federal Association of Aircraft Manufacturers forecast an early resumption of aircraft production ? Had not the Blank Office—nucleus of today's Defence Ministry— spent five years in planning the new German Air Force ? Had not, finally, German aeronautical research been reactivated, admittedly on a modest scale, yet in active contact with similar research in other countries ?

To observers beyond Germany's frontiers there could be no doubt the young Federal Republic was in the unique position of being able to start afresh, free of all ballast. No less important, there were ample funds behind the German plans.

Whether there really was a genuine over-all concept, however, was another question.

*

May 1957 . . . Review of the past two years

The aircraft industry. — In the summer of 1956 the value of the Air Force's procurement programme, to be spread over several years, was given as around DM 5,000,000,000. Only a bare 10 % of this sum, however, was to go to the *German* industry, for the following projects : licence production of the *Noratlas* twin-engine transport, the *Magister* jet trainer and the P. 149 trainer and communications aircraft, and production of the German-designed Do 27 communications aircraft. Such was and still is the backlog of the German industry, which was still practically non-existent on the day the contracts were awarded and had to wait for the advance payments in order to buy its tooling. However, maintenance and repair contracts for foreign aircraft may expand work programmes and increase capacity.

Such of the old firms in the aircraft industry as have survived the lean years are today engaged on the programme outlined above, the financial rewards of which should not be overestimated, since the Defence Ministry's rearmament plan provides a total loan of only DM 35,000,000 for the German aircraft industry.

The *Air Force.* — In the 1957 budget the aircraft to be purchased for the initial equipment of the Air Force are valued at DM 895,000,000. In addition there are the fighter-bombers and reconnaissance aircraft provided by the United States under the arms aid agreement. On the whole the Air Force build-up appears to be proceeding so far more or less to plan.

When Lieutenant General Josef Kammhuber took up the post of Air Force Inspector a year ago, he stressed the need for a clear separation between tactical air force units and the units to be used for local defence. This necessitated an expansion of the organization programme. Meanwhile training of flying and technical personnel got under way, unaffected by these discussions, with 1960 being set as the target year.

This is where the troubles begin, as the Federal Government does not yet appear to have made up its mind to execute the land requisition law in order to provide the needed airfields. Thus the four fighter-bomber wings which are to be set up by the end of 1958 must be housed as " guests " at existing airfields occupied by the Western Allies. What is worse, however, is that the delay in the airfield programme will probably put the Air Force's building programme back at least a year.

The real dilemma facing the Air Force Inspector is, however, less a military than a political one. German politicians do not yet seem to have come to an agreement among themselves on the aims of rearmament. Is the object merely to keep the promise made to N.A.T.O., or does Germany's proximity to the Iron Curtain oblige her to do something about protecting the civil population and maintaining her identity as a nation ? Or has the situation perhaps meanwhile changed so fundamentally that there is now no potential adversary against whom the alliance with the West and the whole rearmament programme might be directed ? In other words, is the only aim of all the efforts to create a military apparatus as a kind of show piece for the West German Republic, to be kept up in the same way as a string of expensive racehorses ?

Recent statements by Defence Minister Strauss and various members of Parliament, officials and officers reveal clearly that Germany wishes to make not a " symbolic " but a real contribution to Western defence. Yet how these desires can be put into effect technically is still far from decided. And this uncertainty constitutes a handicap for General Kammhuber, besides damping the ardour of all who are concerned with rearmament.

The Air Force still does not know for certain whether it can count on a German aircraft industry in due course. It does not know if and when its equipment can be replaced by German-designed and German-produced aircraft. It is completely in the dark as to whether the present nucleus of a German aircraft industry is capable of executing large-scale development contracts. Without a clear answer to such questions as these, neither the Defence Minister nor his Air Force commander can take any stand on the vital question involved in any rearmament planning ; namely, how can the Air Force's combat efficiency be ensured ? The unbiassed observer is bound to ask whether the Defence Minister can decide this for himself, or whether he is not bound by the decisions of the Finance and Economics Ministers, one of whom sees the whole problem only from the point of view of currency stability, while the other is interested solely in maintaining foreign trade.

This singular organizational situation makes it impossible, for example, for the Air Force Inspector to rely on a section of his own Ministry in technical matters. The restrictions placed upon him even go so far as to forbid him to have any independent contact with manufacturers, designers or scientists. Like other democratic countries, the Federal Republic must also pay tribute to bureaucracy.

*

In the autumn of 1956, when Federal Defence Minister Franz Joseph Strauss succeeded Theo Blank, the contention was widely expressed in West Germany that the days of uncertainty were past, that systematic work would now begin. But it was overlooked that the forthcoming elections would inevitably cripple the initiative of all active politicians. It was also forgotten how much painstaking work would be needed inside the Defence Ministry in order to provide a solid basis for creative reorganization.

Strauss, however, is credited, with some reason, with being fully aware of the deficiencies in his Ministry, not only in the administrative but also, and even more so, in the technical field, and with being determined to remove them. A decisive role in this direction will be played by the future " Technical Under-Secretary ". The choice of suitable personalities for this post, with both the requisite amount of technical knowledge and a high degree of independent judgment, is probably very small.

No matter on whom the choice falls, *Bundeswehr* officers are convinced that the ministerial bureaucracy will not accept without opposition any man who does not fit in with their own ideas.

However that may be, technical decisions will not take their place as equals alongside administrative questions until after the elections and the appointment of a Technical Under-Secretary. Not until then will the time have come when the Defence Minister and his military inspectors can rely on expert advice in the execution of their defence tasks.

. . . Au revoir, then, until the spring of 1958.

The Need for Automatic Air Traffic Control Systems

by Anthony Martienssen, N.V. Hollandse Signaalapparaten, Hengelo (O.), Holland

In the first place, why does one need an automatic air traffic control system ? The short answer simply is : safety. Traffic density during peak periods in certain busy centres is already reaching the point at which the present system of what one might call manual air traffic control is dangerously overloaded. The long answer, which is necessarily more complicated, is the question of efficiency. The advantage of going over to automation is not only to be able to do more things more quickly, but also to be able to achieve a degree of efficiency that is beyond most human beings.

In air traffic control this means ensuring that in any traffic situation each aircraft will be able to follow its optimum flight path as nearly as possible, without running a risk of collision. The aim of automatic air traffic control, therefore, is to achieve the maximum possible handling capacity of the system, and to reduce delays to a minimum. The importance of this may be better appreciated if it is realised how great the cost of inefficient operations is to an airline.

On a DC-8, for example, the depreciation rate is in the neighbourhood of $4,000 a day. This means that an airline operating DC-8's must achieve a high rate of revenue-earning flights if it is to make its operation pay. Not only must the aircraft be kept flying, but the time between flights must be as short as possible. An air traffic delay, therefore, apart from the high cost it might mean in fuel, also means a dead loss in revenue-earning capacity to the airline. And if it is also realised that delays tend to build up, so that, say, a three hours' delay during a North Atlantic flight —by no means uncommon today—may delay the turn-round of an aircraft by as much as twelve hours, thereby losing the use of that aircraft for the return trip, it will be seen that the cost of inefficiency may well become the most significant cost in civil aviation operations in the future.

There is a further point of importance to government civil aviation authorities—who receive little of the direct profits of efficient operations, but who have to bear the cost of providing the facilities. It is that a nation's trade is directly linked to the efficiency of its transport system. It is no accident that the two great trading nations, Holland and England, also possess what are probably the two most efficient port authorities in the world—Rotterdam and London. What is true of harbours is also true of airports, and the trading capacity of countries will more and more depend on the efficiency of their air traffic system.

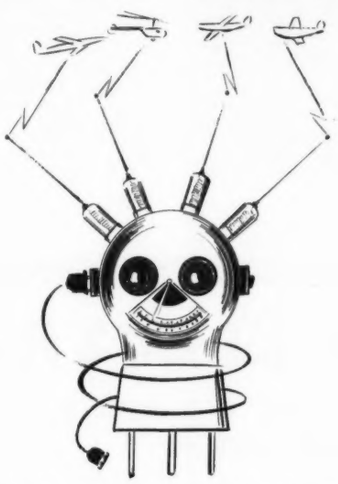
For these two reasons, safety and efficiency, a radical improvement in air traffic control has become essential. The difficulty is to decide what form the improvements should take. What sort of black boxes do we need, and where do we want them ? There is an embarrassing choice of possibilities, ranging from automatic air-to-ground data transfer links to sophisticated systems employing the whole gamut of modern computer and radar techniques. At least part of the delay in modernising air traffic control systems is due to the difficulty which authorities face in choosing the system to use.

One can, however, derive certain basic principles governing an air traffic control system, and then, from these basic principles, make a choice of the necessary equipment. In discussions with airlines and governmental civil aviation authorities it has been possible to evolve such principles. These are :

a. *The equipment should not involve any major change in flying procedures or in the present air traffic organization.*

It is possible to conceive an entirely different air traffic control system—for instance, one based on the fighter control system evolved by the Royal Air Force during World War II—but, from the point of view of practical politics, to bring into force an entirely new organization would be as difficult as, say, changing the road traffic in England from the left-hand to the right-hand side.

b. *The equipment should be basically " ground " equipment,* that is, it should not require special equipment in aircraft other than the radio and navigational aids now carried. The reason for



this principle is, firstly, the difficulty of ensuring that all aircraft will be fitted with such special equipment ; an aircraft not so fitted might cause chaos in a system which was entirely dependent on such equipment. Secondly, the expense of fitting special equipment in all civil aircraft would be very high indeed and might well be beyond the means of the smaller airline companies and of private owners. Finally, it is likely that there would be considerable delays in obtaining international agreement for such equipment and hence considerable delay before an air traffic control system based on such equipment could be introduced into service.

c. *The system as a whole should be capable of being built up " brick by brick ".*

Firstly, because of the expense of modern equipment, installing the system by degrees enables this expense to be spread over a number of years, while at the same time bringing about an immediate improvement from the moment the first brick is laid. Secondly, brick-by-brick building enables full advantage to be taken of the subsequent invention of new devices. Thirdly, countries with comparatively low traffic densities will still be able to use certain items which they may nevertheless need, without having to install the complete system.

There is, however, a big gap between principles and the hardware necessary to put the principles into practice. In most countries, effort has been directed more towards disconnected gadgets than to comprehensive systems. There is, indeed, a general tendency to build a system round a gadget, rather than the other way around, which is not the way to get the best results. There are three main trends of development.

The first is towards *airborne equipment* : better and more accurate navigation systems (Tacan, Vortac, Decca, Doppler radar and inertial systems), automatic air-to-ground and ground-to-air communication links, anti-collision radars and radar transponders. All these devices have their part in aviation, but none go very far towards solving traffic handling problems as distinct from navigation or communication problems.

The second trend is towards a much greater use of ground radar. Networks of long-range radar stations are being built in America and Europe with the object of providing the air traffic controller with an up-to-date picture of the air situation. There have been several improvements in radar displays, both in clarity and size, and there is also the development of airborne transponders for the identification of aircraft, and the CHARACTRON technique of " writing " on the radar tube the call-sign and other relevant data of the aircraft.

While this development of radar is to be welcomed as a major contribution to the solution of the problem, in the present state of the art, it cannot be used as a primary aid : the radar set that will never break down, that is free from all weather interference, and that will guarantee detection of all aircraft within its range has still to be constructed. Nor is there much clear thinking about *how* the long-range radar should be used. It is not enough, for instance, simply to present the controller with a picture of 60 to 70 blips on a PPI, and expect that that will automatically solve all the problems. This, of course, is one of the reasons why there is so much insistence in America on the development of secondary radar—that is, transponders in aircraft which can be coded to give a distinctive signal on the PPI. But here again there is the fundamental weakness inherent in a system dependent on airborne equipment. *Long-range radar, in fact, can only be of help if it is properly integrated into a complete air traffic control system.*

The third trend in A.T.C. developments is to be seen best in the C.A.A. Technical Development Centre in Indianapolis. The trend there is to concentrate on *improving the mechanics of the present system,* and there is an impressive array of hardware on view. There are automatic progress strip printers, automatic progress boards, and an automatic Flight Plan filing system consisting of a large magnetic memory drum which operates according to the normal data processing techniques. At present, an IBM digital computer is also being tried out to compute Flight Plans automatically. Briefly, the system accepts Flight Plans and automatically computes ETA's at reporting positions, automatically prints the progress strips, and automatically displays the information on the progress board. It automatically distributes the

relevant data to each sector in the control centre and provides a facility for push-button data transfer from one control position to another.

The automatic equipment at Indianapolis will, it is true, give the controller much better tools for his job, but there will still be a very big discrepancy between traffic plans made by individual controllers, and there is no guarantee that the equipment will of itself increase the handling capacity of airports or lead to a more efficient use of air space.

It will by now be clear to the reader that the real difficulty in air traffic control is the formation of optimum traffic plans. Random traffic has somehow to be " derandomized " ; air space has to be more efficiently used ; handling capacity has somehow to be increased. There are, as far as I know, only three systems which offer a genuine solution to these problems.

The first is SAGE. A committee in America has for some time now been examining the possibility of fitting civil aviation problems into SAGE. It is, however, doubtful whether SAGE will be able to carry the additional load of civil problems.

Secondly, there is the VOLSCAN system which again is a military system, but which could conceivably be adapted to civilian needs. VOLSCAN works from basic radar-derived data about the positions of aircraft for which it computes flight paths back to a given base which will not conflict with the flight paths of other aircraft. Provision is made for the automatic transmission of instructions to aircraft, and it integrates the radar in a satisfactory manner. It has not, however, been designed to fit into an airways system, and though, like SAGE, it could be adapted to do so, it might be another case of twisting the system to fit the gadget.

Finally, there is our own system which is being developed in Holland—SATCO. The easiest, though not very accurate, way of describing SATCO is to say that it is similar to the automatic signalling system of the railways, but operating in three dimensions and at electronic speed. It is based on the existing air traffic system, and it includes the " business machine " features of the equipment at Indianapolis. The outstanding features of the system are a special-purpose digital computer for solving air traffic control problems, an integrated tracking radar system, and an automatic data transfer system which will operate over the normal telex network.

Flight plans, flight plan departure messages, or transfer or control messages from adjacent control centres are fed into the system on a normal teleprinter. The telex code is then automatically converted into the various codes required by the processing equipment. The flight path of the aircraft, with the ETA's at reporting positions, is automatically calculated, conflicts with other flight paths are discovered and a safe flight path is computed. The safe flight path is then recorded on a magnetic memory drum, displayed automatically on various " tote " type display panels, both in the control centre and in the control tower of the airfield concerned, and printed on a form of progress strips. Then as soon as actual details, as distinct from forecast details, of the aircraft's flight are received, a correction, if necessary, is made to the flight plan and a corrected safe flight path is computed. At the same time the tracking radar system is brought into play to check firstly the position of the aircraft and secondly its course and speed, these details then being used as yet an additional check on the operation of the computer. Moreover, after initial identification, the tracking radar system will automatically continue to check the position and progress of the aircraft every minute or two minutes, correcting as necessary the predicted safe flight path.

From the controller's point of view, the system automatically presents him with the times and heights at which aircraft should be over reporting positions in order to achieve an optimum traffic plan—with an indication of changes that may have had to be made to the original Flight Plans of individual aircraft. There is also a " clear-view " display of the air situation which, by the turn of a knob, can be projected into the future.

This has necessarily been a much condensed account of a complex problem and complex solutions. There are many possible extensions of these systems in order to make them eventually fully automatic, and it may not be very long in the future before air traffic control is reduced to an illuminated panel in the cockpit of the aircraft. However, it should always be borne in mind that electronic brains can do no more than they are instructed to do by the human brain, and it is almost impossible to make a computer that will be able to take into account every possible contingency in aviation. For this reason, now as always, the human controller is indispensable.

LOCKHEED ELECTRA

Equipped to handle —80° F. to 400° F. with AUTO-LITE 350 wire

Wide scale, high speed jet travel will be a reality with the new Lockheed propjet Electra. The Electra will be powered by thrifty and quiet Allison engines.
Like many other airframe manufacturers, Lockheed finds the extra temperature range performance of Auto-Lite 350 Wire ideally suited to jet aircraft demands. Many manufacturers are finding that Auto-Lite 350 Wire reduces over-all production costs, too, compared with other high-temperature wires.

- Flexible at temperatures below —80° F.
- Smokeless
- No discoloration at maximum operating cable temperature, or at an altitude of 60,000 ft. as measured at the equator
- Resistant to modern aircraft hydraulic fluids, lubricants and fuels for both reciprocating and jet-type engines
- Flame-resistant
- Easy printing of circuits with conventional marking machines
- Free stripping
- Meets Spec. MIL-W-8777, U.S.A.F.
- Manufactured in sizes 22 through 2/0

THE ELECTRIC AUTO-LITE COMPANY
Export Division, Chrysler Building, New York 17, N.Y., U.S.A.

FLEXIBILITY

makes Temco's TT-1 your...

soundest investment in jet aircraft

Tomorrow's jet age requirements are built into today's Temco TT-1 tandem jet trainer. Selected by the U. S. Navy as the U. S. A.'s first primary jet trainer, the rugged TT-1 meets the most exacting standards for today's pilot training. In addition, the all-new aircraft has a growth factor that will keep it "new" for years to come.
With true jet performance, plus economical operation, the TT-1 will meet every requisite of *your* military training program.

PERFORMANCE STATISTICS

ENDURANCE: 1.5 hours
MAXIMUM RANGE: 240 nautical miles
SERVICE CEILING: 30,000 feet
MAXIMUM DIVE SPEED: 450 knots
MAXIMUM SPEED: 285 knots
RATE OF CLIMB: 1900 feet per minute
TAKE-OFF DISTANCE: 3000 feet, over 50-foot obstacle
STALL SPEED: 63 knots
AEROBATICS: Unrestricted for all conventional maneuvers

For further information on the TT-1, contact

TEMCO EXPORT CORPORATION

1625 Eye St., N. W., Washington, D. C., U. S. A.

cae
contractor maintenance keeps them flying

cae Maintenance Teams are set up to go into action immediately ... in

EUROPE
NORTH AMERICA
SOUTH AMERICA

We supply Field Service Representatives, Flight Line Crews, Mobile Repair Parties and complete Depot Facilities and Spares

for Flight Line Maintenance,
Squadron Level Maintenance,
Field and Depot Maintenance of
RADAR FIRE CONTROL SYSTEMS, AIRCRAFT AND TACTICAL SIMULATORS
and other specialized Electronic Instruments and Systems

CAE preventative and corrective maintenance has proven itself in Canada and overseas by freeing manpower and aircraft for the main job. It sets up rigid time expired schedules at the end of which all material is brought back to zero hour life.

Department 1 — Maintenance Division

CANADIAN AVIATION ELECTRONICS LTD.

cae

P.O. Box 630, Station "O", St. Laurent, Que. Canada
Cable address: CANAVALEC, Montreal

The Largest Canadian-Owned Electronics Company

The French Anti-Aircraft Robot (T.P.C.) is a Veritable Electronic " William Tell "

Operation " MISTRAL " was the name under which a demonstration, organized by the Ministry of National Defence (Directorate of Arms Development and Production), was made to N.A.T.O. experts at Toulon on March 15th, 1956, of a new French fire control system for medium-calibre anti-aircraft artillery.

The complete equipment consisted of an artillery section—type 40 L 70—equipped with a " Télépointeur-Calculateur TPC ".

The latter forms a homogeneous fire control system designed for 40-mm anti-aircraft batteries. The radar provides automatic tracking of the target, the computer (*calculateur*) built by Compagnie Générale de T.S.F. and incorporated in the equipment, transmits firing data to two separate groups of guns, extrapolating the trajectory followed by the target and making allowance for parallax and for atmospheric and ballistic conditions.

The programme comprised automatic tracking exercises against high-speed aircraft, with live fire on a towed target and monitoring by industrial television.

To enable the N.A.T.O. delegations to appreciate the capabilities of the " télépointeur-calculateur ", this equipment had been incorporated into a complete 40 L 70 gun section; in addition, the section had been provided with information facilities similar to those which would normally exist in the zone of action of a 40 L 70 section.

In developing the complete equipment, Compagnie Française THOMSON-HOUSTON was responsible for the design and manufacture of the radar and optical tracking equipment, its servo-mechanisms and the vehicle.

The TPC permits the independent tracking by radar of targets situated within a radius of 20 miles; it ensures acquisition, automatic tracking by radar or optical tracking (with radar supplying the distance).

The follow-up controls enable the TPC to track automatically targets flying at sonic speeds and at close range; the angular errors lead to exceptionally small measuring errors.

To enable supersonic aircraft to be tracked with the maximum efficiency, a system of feed-back controls providing very close contact between the radar, the rotating platform and the computer has been designed; this system permits the speed calculated by the computer to be used to predict the movements of the target and to correct the position of the radar antenna.

Thanks to the feed-back system, tracking oscillations about the mean position, for targets at close range, are considerably reduced, radar noise is eliminated, and a target flying vertically overhead can be tracked.

The high qualities of the radar and the method used to combine them have made it possible to satisfy two contradictory requirements, namely precision and rapidity of prediction, the most difficult part of preparing the fire of anti-aircraft artillery.

During the demonstration at Toulon, the acquisition and tracking of jet aircraft took place under what were the most difficult conditions for radar.

Firstly, the presence of a considerable quantity of permanent echoes around the site did not prevent acquisition; though not recommendable from the radar point of view, this type of terrain may well be encountered in many tactical situations.

Secondly, the aircraft chosen, the " Mistral ", is among present-day fighters with the smallest reflecting surface, greatly inferior to that of a " F 84 ", " Sabre " or " Mystère " type jet fighter.

Finally, atmospheric conditions were bad.

Nevertheless, it was possible to assess the quality of the tracking from observation of the industrial television images and to judge the overall accuracy from the firing at the towed target.

The demonstration, which was organized with the assistance of the Naval and Naval Air Arm Staff, the Air Force Staff and the local Anti-Aircraft Defence Zone, was, despite the unfavourable atmospheric conditions, particularly successful in the unanimous opinion of the N.A.T.O. experts and observers from the various foreign countries.

Some Technical Solutions

The Radar Antenna is the first component in the tracking chain: The T P C's VHF radiation is obtained through a waveguide's " illuminating " a hemispherical reflector. The decision to make the reflector vibrate in relation to the waveguide was influenced by three considerations: the deflection angle of the radiation is then double the angle of mechanical inclination, secondary lobes are substantially reduced, and uniformity of scanning is maintained.

Targets detected by the T P C radar are displayed to the operator on two scopes, one of them being an inverted I-scope which disposes circularly on the screen the high-speed scanning cone produced by the antenna's rotation; this facilitates watch-keeping and distributes nearby permanent echoes on the edges of the scope. The echo of a target appears on the scope in the form of a luminous crescent which becomes a circle when the target is situated in the axis and is thus illuminated during a full revolution.

The servomechanisms for both azimuth and elevation consist of a servo amplifier, an amplidyne and a continuous current motor: the dynamic characteristics of the servomechanisms, passbands, speed and acceleration constants are such that tracking of high-speed targets at very short distances from the radar is carried out under very good conditions.

The rapidity with which the T P C was set up and the facilities provided for the maintenance and operating personnel were commented upon favourably.

CHARACTERISTICS

Mechanical data

Overall length (with trailer shaft)	18.8 ft. approx.
Overall width	7.5 ft.
Ground clearance (centre of forward axle)	1 ft.
Wheel track	6.5 ft.
Height (road position)	9.7 ft.
Total weight (excl. computer)	4.5 tons

Frequencies

Transmission

Frequency range	variable from 8,900 to 9,500 Mc/s
Peak power	> 70 kW
Pulse width	0.5 μ/sec
Pulse repetition rate	2,000 c/s

Antenna

Reflector diameter	3.6 ft.
Gain	$\geq$ 37 db
Side lobes	< 23 db for 0 deflection
Beam width for 3 db	2°
Eccentricity of beam	1°
Ellipticity of circular polarization	0.93

Reception

Noise factor	13 db
Bandwidth	4 Mc/s
Intermediate frequency	36 Mc/s

Scopes

Two scopes: a) inverted I-scope; b) A-scope	
Diameter of screens	5 inches
Range markers	5 km

Performance

Search range	20 miles
Tracking range	10 miles
Radar acquisition accuracy: $\pm$ 10 ‰ in azimuth and elevation	
Automatic tracking accuracy: $\pm$ 22 yards maximum localization error in all directions	

Power supply (127/220 three-phase)

Consumption excl. computer	19 kVA
Consumption incl. computer	26 kVA

The TH.D.1225 tracker includes a trailer on which are mounted: the rotating platform and the radar unit, the entire servomechanisms, the computer.

Trailer—Four-wheel trailer—unpuncturable tyres—carrying cabinets housing the amplifiers for the servomechanisms and the azimuth/elevation amplidynes, the 400 c/s alternator, etc.

Platform—The rotating element comprising: the antenna unit and its mechanisms; the radar unit; the *radar operator's* post with his observation scopes and the *optical tracker's post* with his binocular telescope.

TRACKER THOMSON CFTH HOUSTON for medium anti-aircraft artillery

The TH.D.1225 tracker developed by Cie Fse Thomson-Houston is a *mobile automatic tracking radar* which functions in the *X band* and supplies with *great precision* the azimuth and elevation coordinates and the distance of the target tracked.

Of necessity combined with a computer [1] mounted on the vehicle, it permits formation of a *complete fire control system for medium-calibre anti-aircraft batteries* [2] (40 mm) which entirely satisfies the requirements of modern Anti-Aircraft Defence, in particular from the point of view of:

facility of operation and maintenance
rapidity of prediction and opening of fire
safety of personnel and protection of equipment
mobility and ruggedness.

It is equipped with:

● *a magnetron with controllable frequency* within a band of 600 Mc/s; easy regulation and reading of frequencies, thus avoiding any possibility of jamming by neighbouring radar;

● *a circular polarization device* enabling the equipment to be used even in rain without loss of performance.

The tracker can follow an aircraft flying at a speed of 450 m/s (875 knots) at an altitude of 1,300 ft. and a horizontal distance of 1,300 ft. from the radar.

It was developed and manufactured for the *French War Ministry*, under the direction of the *Arms Development and Production Section.*

Operation

The tracket is manipulated by three operators:

the *radar operator* } mounted on the vehicle
the *optical tracker* }
the *computer operator*—crew chief: possibly supplemented by:
a *ground observer* equipped with a collimator.

It operates as follows:

● **Search**—The antenna scans, in one second, the air space *within a radius of 20 miles* inside a cone with a total aperture of 24°, the axis of which can be varied at will in azimuth and elevation.

● **Acquisition**—The target is detected and maintained in the axis of the scanning cone (*angular acquisition*) and then located in distance (*distance acquisition*), when the latter is reduced to *less than 10 miles.*

● **Tracking**—Once the target has been detected in direction and distance, the radar ensures automatic tracking and transmits to the computer its azimuth and elevation coordinates and distance.

● **Feed-back control**—*The tracker's normal method of functioning.* As soon as the computer has determined the speed (2''), it remotely controls the radar antenna into the presumed direction of the target, assuming that the target maintains the speed and heading previously computed. The automatic tracking device then compares the real position with the computed position and sends to the computer data enabling the speed estimate to be corrected. *This original device reconciles the requirements for precision of tracking and rapidity of calculation.*

Simultaneously, the computer works out firing data for the guns affected by the corrections obtained.

● **Reconstructed tracking**—In this position the computer extrapolates a straight-line course at constant speed, thus making it possible either to continue tracking " by memory " (e.g., if the radar is jammed or loses the target), or, with the computer disengaged from the radar, to proceed to the acquisition of a second target, while fire continues on the first with the aid of the computer only.

Finally, the " OPTICAL " operators can replace the radar operator, in which case they ensure:

Optical tracking: The telescope of the optical operator (or ground observer) enables the antenna to be aimed in direction.

Optical control: As with radar feed-back control, the error transmissions in this case being supplied by the optical tracking lever.

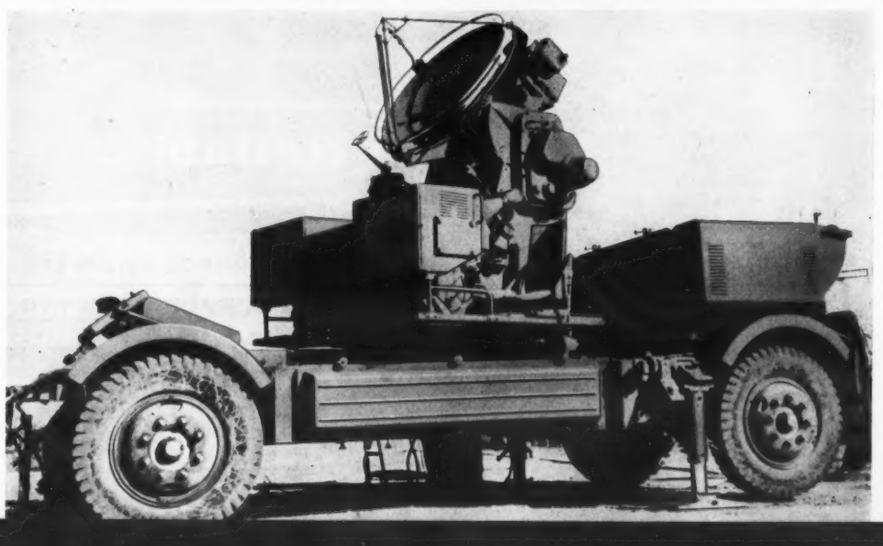
The tracker includes a *trailer* on which are mounted the rotating platform and the radar unit, the entire servomechanisms and the computer.

Trailer—Four-wheel trailer carrying cabinets housing the amplifiers for the servomechanisms and the azimuth/elevation amplidynes, the 400 c/s alternator, etc.

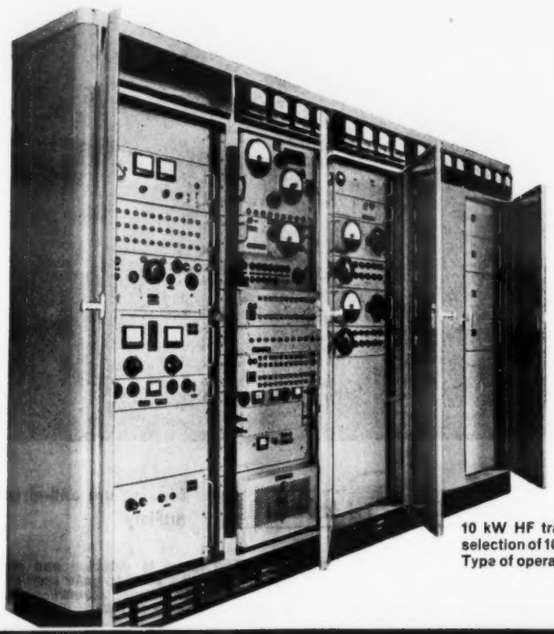
Platform—The rotating element comprising the antenna unit and its mechanisms, the radar unit, the *radar operator's* post with his observation scopes and the *optical tracker's post* with his binocular telescope.

[1] *The computer is not manufactured by C.F.T.H. In France, use is made of the P.H.F.40 computer built by Compagnie Générale de Télégraphie sans Fil (C.S.F.).*

[2] *The tracker can be adapted to other calibres (57 or 75 mm) by modifying the computer's ballistic characteristics.*



HF-VHF-UHF air traffic control equipment



10 kW HF transmitter with remote selection of 10 frequencies: 1.5 to 28 Mc/s
Type of operation: A1, A2, A3, A4, A3+F1 F1, F2, F3, F4, F6

HF transmitter and receiver systems
1.5 ... 28 Mc/s 100 W / 500 W / 1 kW / 10 kW

VHF transmitter and receiver systems
100 ... 156 Mc/s 100 W / 1 kW / 10 kW

UHF transmitter and receiver systems
225 ... 400 Mc/s 10 W / 100 W / 1 kW

All associated antennae, measuring equipment, remote controls and auxiliary equipment.

ROHDE & SCHWARZ · MÜNCHEN 9

ESC

Drop Forgings and Steels

used in the FOKKER F.27 *Friendship*

For Reliability in Service

ENGLISH STEEL FORGE AND ENGINEERING CORPORATION LTD
ENGLISH STEEL ROLLING MILLS CORPORATION LTD

Wholly owned subsidiary companies of

ENGLISH STEEL CORPORATION LTD., Sheffield, England.

L.A.I.'s network of more than 25,000 miles connects Rome and other major Italian cities with the world

FLY LAI

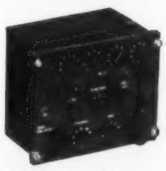
LINEE AEREE ITALIANE

EDO AIRBORNE LORAN

The Edo Airborne Loran has been designed specifically to meet the requirements for a compact, pilot-operated Loran unit for dependable, accurate long-range navigation. Edo Loran has already been specified by several major trans-oceanic airlines for their new jet aircraft. Technical manual available on request.

COMPACT UNITS FOR COCKPIT INSTALLATION

7.62 cm display for instrument panel mounting.



Small, panel - mounted command control provides directly-read data. Receiver unit (not shown) occupies 3/4 ATR rack.

Edo CORPORATION
Since 1925
COLLEGE POINT, NEW YORK, U.S.A.

Verlangen Sie unseren Sonderprospekt TP/I

6 x 9 cm
2¼ x 3¼"

TECHNIKA press

DER ZEIT VORAUS . . . . .

ist die Technik, bringt neue, rationellere Erfindungen. Utopien von morgen werden Wirklichkeit von heute. Technik ist Fortschritt, schafft neue Welten.

Luftfahrt und Fotografie sind nicht mehr voneinander zu trennen. Modernste Technik begegnet sich, eröffnet völlig andere Perspektiven der Ferne und des Details.

Die neue Schnellschuß-Kamera TECHNIKA-Press löst durch ihre Wendigkeit und Vielseitigkeit, unterstützt durch Objektive höchster Leistungsfähigkeit die Probleme moderner Luftbildfotografie. Ständige Schußbereitschaft, Erübrigung zusätzlicher Kameras, automatische Kupplung der Objektive mit dem Entfernungsmesser, Schnellwechseleinrichtung für Rollfilm, Platten und Planfilm, Filmpack in Schwarz-weiß und Farbe, verstellbarer Patent-Formgriff mit eingebautem Drahtauslöser sind einige markante Vorteile der

dynamischen Kamera für dynamische Bilder!

Linhof PRÄZISIONS-KAMERA-WERKE MÜNCHEN 25

LORENZ

LORENZ

pioneers for more than 25 years
in radio aids to air navigation

VOR VHF Omnirange according to CAA specifications
ILS Instrument Landing System
FB II Fan Marker
ZFB MF Homing Beacon
CONSOL for long range navigation

C. Lorenz AG Stuttgart

ST

FOR SAFER HIGH ALTITUDE FLYING

The Scott Helmet and Pressure Suit Test Console

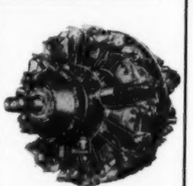
Here is the world's safest, simplest, most versatile, helmet and pressure suit testing and training aid. Wherever a partial pressure suit is used there is an imperious need for the Scott Model SC-6 Console in personnel training, periodic indoctrination and above all for the important functional testing of helmets and suits in preflight operations or ready rooms. Determines whether a man is physiologically capable of adapting to high positive pressure conditions. Will automatically maintain the proper ratio of breathing pressure to applied suit pressure. Is an indispensable piece of equipment for every up-to-date military air base.

Write for complete information.

SOUTHERN OXYGEN CO.

250 West 57th Street, New York 19, N.Y., Cable Address: SOXCOGEN

one of the world's great inventories of new and used, WRIGHT & PRATT WHITNEY engines and parts



Checked to C.A.A. specifications, located on our own premises, our complete, extensive stock is ready for immediate shipment anywhere in the world! Write, wire or phone your inquiry today.

R-985
R-1820
R-1830
R-2000
R-2600
R-2800
R-3350

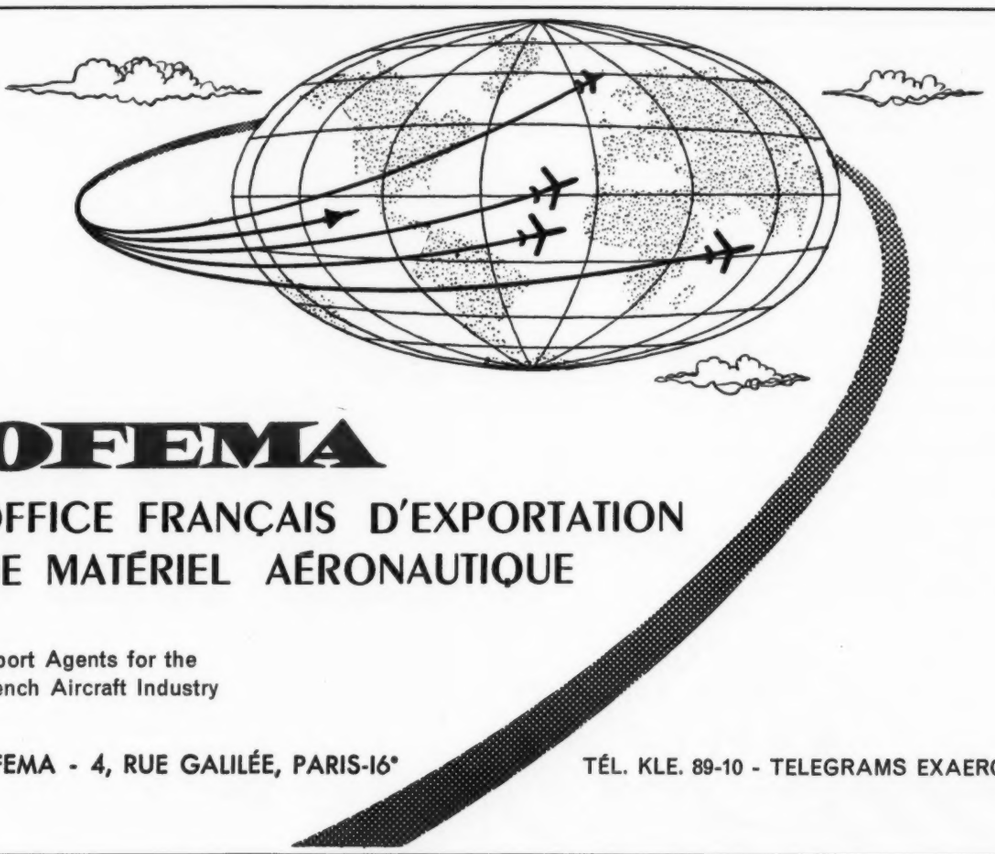
CALIFORNIA AIRMOTIVE CORPORATION

7139 Vineland Ave • No Hollywood, Calif., U.S.A.

Phones: POplar 5-6202 • STanley 7-3361

Cable Address: CALMOTI

All engines and parts are certified by CALIFORNIA AIRMOTIVE ENGINEERING CORP., C.A.A. Approved Repair Station No. 3890, Powerplant Class II



OFEMA

OFFICE FRANÇAIS D'EXPORTATION
DE MATÉRIEL AÉRONAUTIQUE

Export Agents for the
French Aircraft Industry

OFEMA - 4, RUE GALILÉE, PARIS-16e

TÉL. KLE. 89-10 - TELEGRAMS EXAERO

KLM

THROUGHOUT THE WORLD - THROUGHOUT THE YEARS!

A Proud History of Pioneering

1919 - KLM is founded at The Hague, Holland, - the *oldest* air company in the world still flying under the same flag.

1920 KLM inaugurates the Amsterdam-London flight which is the *oldest* air route in the world still being flown by the same carrier.

1921 KLM opens the *first* air traffic booking office in the world.

1925 KLM is the *first* to make use of air-cooled engines and all-metal propellers.

1927 - KLM makes the world's *first* intercontinental charter flights.

1929 KLM opens the *longest* air route of that time: Amsterdam-Jacarta.

1934 KLM, as the *first* airline outside the U.S.A., introduces all-metal Douglas DC-2 and wins the London-Melbourne Air Race. Two years later KLM is the first European company to buy the DC-3.

1943 - KLM, as first non-U.S.A. carrier, orders the Lockheed Constellation.

1946 KLM, though heavily shattered by the war, is the *first* European airline to open a post-war North Atlantic service.

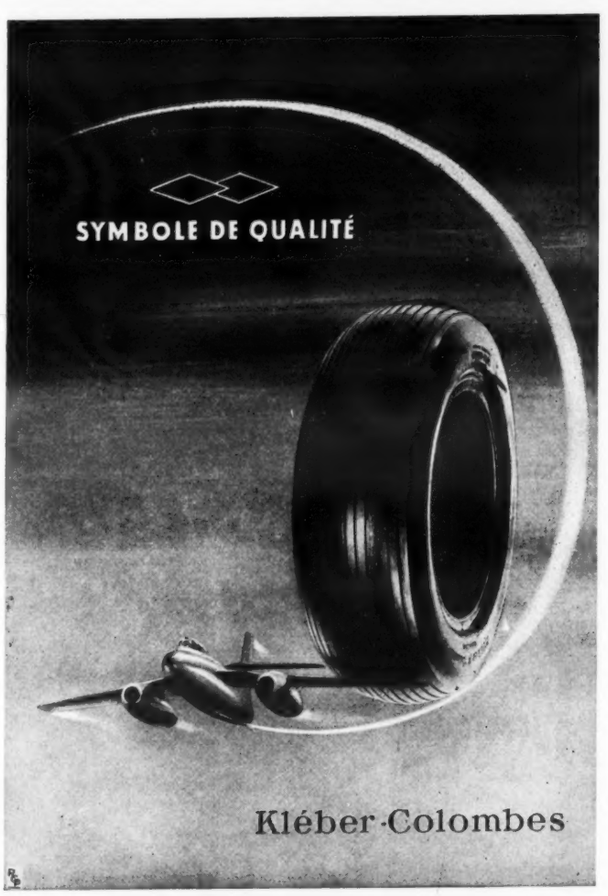
1948 - KLM is the first European airline to buy the Convair Liner.

1950 - KLM is the first European airline to be specially authorized by the U.S. Government to overhaul aircraft of U.S. air companies.

1953 KLM is the world's first airline to operate the turbocompounded Lockheed Super Constellation.

1956 - KLM is the *first* carrier outside the U.S.A. to order the jet-engined Douglas DC-8 and the turboprop Lockheed Electra.

KLM
ROYAL DUTCH AIRLINES



an event
of unusual importance to Italy !

L.A.I. has pleasure in announcing the introduction into service on its European network of the Vickers VISCOUNT, the most modern of airliners, fitted with 4 powerful Rolls-Royce turboprops.

VICKERS VISCOUNT
with
ROLLS-ROYCE
engines

FLY LAI

How far can you see into the future?

AIR DEFENCE AND CONTROL SYSTEMS

AUTOMATIC ANTI-AIRCRAFT SYSTEMS
AUTOMATIC AIR TRAFFIC CONTROL SYSTEMS

- FIRE CONTROL EQUIPMENT
- TRACKING RADARS
- RADAR WARNING SYSTEMS
- DIGITAL COMPUTERS
- SERVO-MECHANISMS

N.V. HOLLANDSE SIGNAALAPPARATEN
HENGELO O. NETHERLANDS

AIRCRAFT and ENGINES

ENGINES

4 cylinders 240 h.p. – 396 lbs.
6 cylinders 305 h.p. – 574 lbs.
8 cylinders 500 h.p. – 737 lbs.

HEATING

Heating and Cooking Stoves
for oil and gas

ÉTABLISSEMENTS

HENRY POTEZ

KLEber 27.83 - 46, Avenue Kléber, PARIS XVI[e] - POTEZAERO-PARIS

SOCIÉTÉ D'OPTIQUE DE MÉCANIQUE
D'ÉLECTRICITÉ et de RADIO

OMERA

ELECTRONIC EQUIPMENT
PRECISION OPTICS and MECHANICS

Transmitters. SARAM-licence airborne receivers
VHF SARAM TRAP.6A
UHF SARAM TRAP.11A
AGA-licence radio beacons
DECCA-licence radar

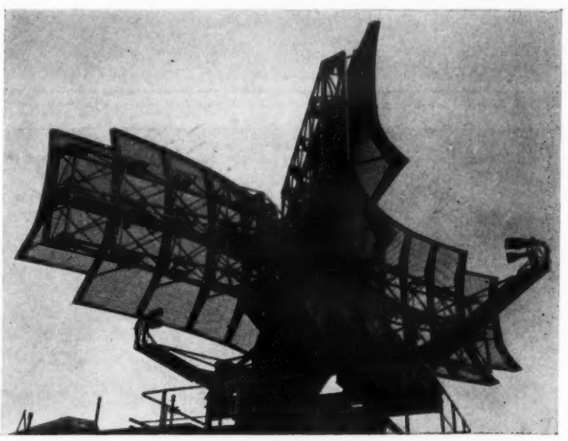
AIR PHOTOGRAPHIC EQUIPMENT
SEPHOT licence
Type 20 and 100 sight recorders
Type 11.30 and 31 cameras

49 rue Ferdinand-Berthoud
ARGENTEUIL (S.-et-O.) — Tel.: ARG 3240

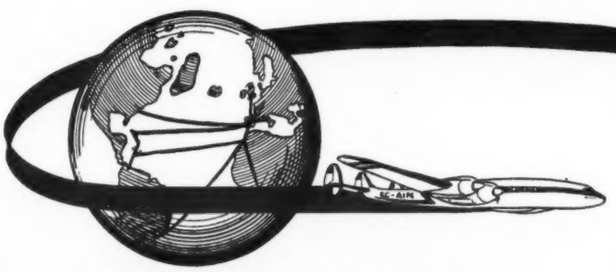
SOCIÉTÉ NOUVELLE DE L'OUTILLAGE R.B.V.
ET DE LA RADIO-INDUSTRIE

43-45, avenue Kléber - PARIS 16[e] - Tel. : KLE 64-71 and 87-10

RA RI DAR



Long-range high-performance surveillance radar :
New system with " staggered beams "



SERVICES LINKING
4 CONTINENTS

Iberia

LINEAS AEREAS ESPAÑOLAS

PILATUS

Pilatus Aircraft Works Stans

Telephone (041) 84 14 46 (Mondays to Fridays)

Design and construction of aircraft
for civil and military use • Production of airframe parts • Overhauls and repairs

Pilatus-Air-Service

Handling and maintenance for taxi services and charter passenger and cargo services
Overhauls and repairs of sports aircraft

Zurich-Kloten Airport
Telephone (051) 93 73 87

Geneva-Cointrin Airport
Telephone (022) 33 53 65

Le succès commande

SOCIÉTÉ NOUVELLE DES

AVIONS MAX HOLSTE

Siège et usine : 11, rue Gosset, REIMS - Tél. 47.26.65 et 47.74.11
Aérodrome : REIMS-SAINT-LÉONARD - Téléphone : 47.58.95

Société d'Applications Radioélectriques
à l'Aéronautique et la Marine

S.A.R.A.M.

Radio-electric design studies

Airborne transmitter-receivers

V H F

Types 5-41 - 5-42 and 5-52

U H F

TR-AP-11A

9 and 11 rue H.-G. Fontaine — **Asnières** (Seine)
Tel.: GREsillons 33-21 and 33-22

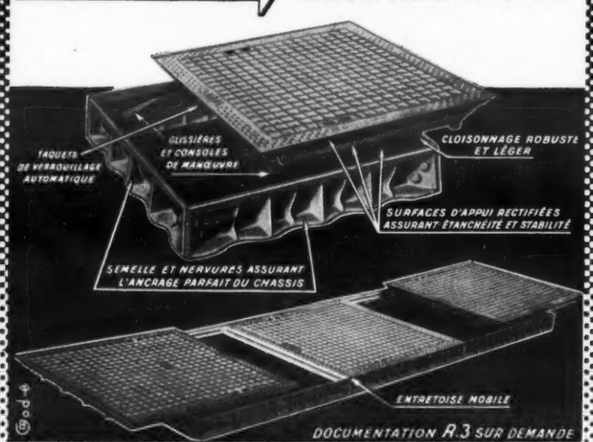
INSPECTION COVERS

SEBEL
MARQUE DÉPOSÉE

IMPERMEABLE
TO WATER AND GAS
STABLE
AUTOMATIC LOCKING

Range of 3 types

LIGHT, *weight 1,650 lbs.*
SIDEWALK, *resistance 5,500 lbs.*
ROADWAY, *resistance 15 tons.*


TAQUETS DE VERROUILLAGE AUTOMATIQUE
GLISSIÈRES ET CONSOLES DE MANŒUVRE
CLOISONNAGE ROBUSTE ET LÉGER
SURFACES D'APPUI RECTIFIÉES ASSURANT ÉTANCHÉITÉ ET STABILITÉ
SEMELLE ET NERVURES ASSURANT L'ANCRAGE PARFAIT DU CHASSIS
ENTRETOISE MOBILE

DOCUMENTATION *R.3* SUR DEMANDE

Cie DES FONDERIES DE MÉRU
SIÈGE SOCIAL ET BUREAUX :
109, Bd Haussmann, PARIS-8e - Tél. ANJ. 08-85
Usines à **MÉRU** (Oise) - Tél. : **127**

RADIO-SWITZERLAND

Limited Company for Wireless Telegraphy and Telephony

MANAGEMENT :
Hauptpostgebäude, Berne. Tel. 2 26 03

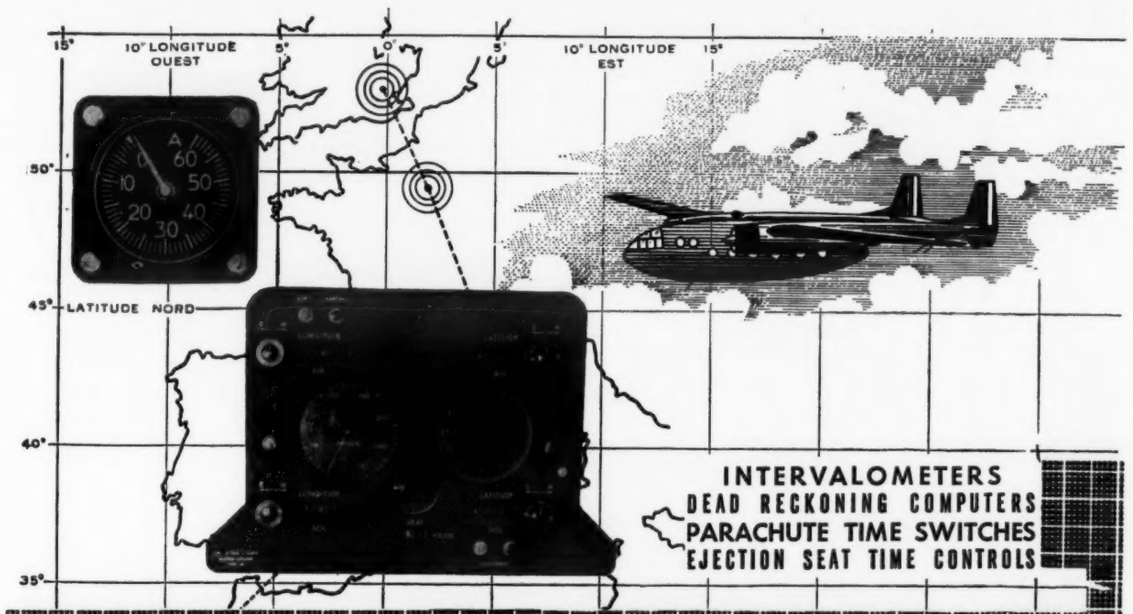
SEND YOUR TELEGRAMS

VIA RADIOSUISSE

Direct wireless connections with all parts of the world

Telegrams « Via Radiosuisse » may be handed in at any Swiss telegraph office

Charges are the same as for wire telegrams



INTERVALOMETERS
DEAD RECKONING COMPUTERS
PARACHUTE TIME SWITCHES
EJECTION SEAT TIME CONTROLS

CROUZET
AVIATION

PARIS : 76, AV. DE LA RÉPUBLIQUE - TÉL. VOL. 85-69

COSTRUZIONI AERONAUTICHE
GIOVANNI AGUSTA

PLANT AND AIRFIELD AT
CASCINA COSTA - GALLARATE

AGUSTA AZ. 8 AIRCRAFT
AGUSTA-BELL HELICOPTERS

3 TIMES CHEAPER

SOFRANCE
K3 FILTERS

When the first of these filters were put into service, users planned for a very long depreciation period.
Today, after 5 years of use, they have discovered that this equipment is actually three times cheaper than other filters.
The reason is simple :
The filters work for **2 to 4 years without replacement, without dismantling, without unsealing.**

SOFRANCE

PARIS : 206, Bd PEREIRE, ETO. 35-19
LYON : 1, RUE FERRANDIÈRE, FRANKLIN 65-91 - 92 - 82-52
LIMOGES : 34, AVENUE GÉNÉRAL-LECLERC 37-26 - 28-23

12

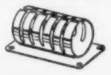
BIRTCHER | TUBE RETENTION AND COOLING DEVICES

As Used In Most U.S. Missiles and Aircraft

TUBE RETAINING CLAMPS

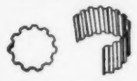
For standard and miniature size electronic tubes and components. Request catalog 3-D.

TEMPERATURE REDUCING CLAMPS



For miniature and subminiature electronic tubes and components. Request catalog 4-KK.

TUBE COOLING SHIELD INSERTS

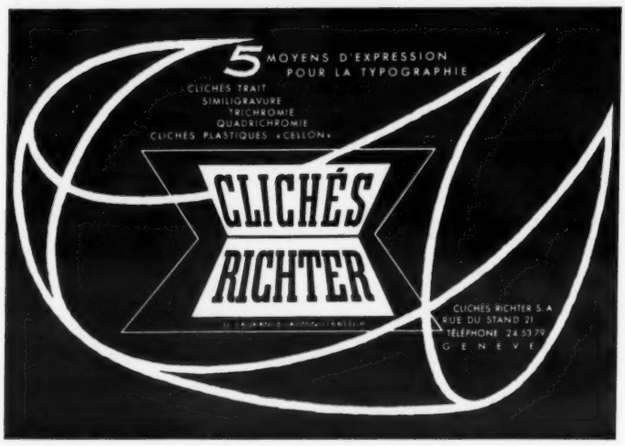


To be inserted inside RF shields on miniature tubes. As developed and specified by U.S. Navy Request catalog B-25.

Catalogs requested will be airmailed immediately

THE BIRTCHER CORPORATION / EXPORT DIVISION

4371 Valley Blvd., Los Angeles 32, California U. S. A. Cable : BIRTCORP



AÉRODYNAMIQUE

Thèmes choisis à la lumière de leur développement historique

by **THÉODORE VON KÁRMÁN**

Chairman, Advisory Group for Aeronautical Research and Development, N.A.T.O.
Former Director, Guggenheim Aeronautics Laboratory, California Institute of Technology

Translated by Rolland A. Willaume
Director, International Exchange Program, A.G.A.R.D.

226 pages, 72 ill. and 4 plates Cloth bound 22,50 Swiss Francs

Also available: German, English and Spanish editions of this book

ORDER FROM YOUR BOOKSELLER or from

INTERAVIA
GENEVA 11 (Switzerland)

LIST OF ADVERTISERS IN INTERAVIA JUNE ISSUE

	Page
Aircraft Radio Corp., Boonton	617
Air France, Paris	536
Allison Division of General Motors Corp., Indianapolis	515
Avro Canada Limited, Malton	512
Bendix International, New York	570, 571
Birtcher Corporation, Los Angeles	616
Boeing Airplane Co., Seattle	537
Bristol Aeroplane Co. Ltd., Filton	533
California Airmotive, Los Angeles	608
Canadair Limited, Montreal	618
Canadian Aviation Electronics, St. Laurent	603
Champion Spark Plug Co., Toledo	589, 590, 591, 592
Contraves Italiana S.p.A., Rome	526
Costruzioni Aeronautiche Giovanni Agusta, Cascina-Costa Gallarate	615
Crouzet Aviation, Valence	615
Decca Navigator Co. Ltd., London	569
Douglas Aircraft Co. Inc., Santa Monica	541
Dunlop, S. A. des Pneumatiques, Paris	609
Edo Corporation, College Point	607
Electric Auto-Lite Co., New York	602
English Electric Co. Ltd. (Aircraft and Aviation Group), London	527, 548
English Steel Corp. Ltd., Sheffield	606
Fairchild Engine & Airplane Corp., Hagerstown	557
Fairey Aviation Co. Ltd., Hayes	523
Fokker, Amsterdam	517
Fonderies de Méru, Paris	614
Garrett Corporation, Los Angeles	572
Goodyear Tire & Rubber Co., Akron	516
Hollandse Signaalapparaten N.V., Hengelo	611
Holste, Avions Max, Reims	614
Iberia, Madrid	612
International General Electric, New York	539
Kléber-Colombes, Paris	610
KLM Royal Dutch Airlines, The Hague	610
Lear Inc., Santa Monica	547
Linee Aeree Italiane, Rome	607, 611
Linhof K.G., Munich	607
L.M.T., Paris	540
Lorenz A.G., Stuttgart	608
Marconi's Wireless Telegraph Co., Chelmsford	524
Minnesota Mining & Mfg. Co., St. Paul	514
Napier & Son Ltd., London	543
OFEMA, Paris	609
OMERA, Argenteuil	612
OMI, Rome	613
Omnipol S.A. Prague	542
Orenda Engines Limited, Malton	525
Philips Gloeilampenfabrieken NV, Eindhoven	530
Pilatus-Flugzeugwerke, Stans/NW	613
Plessey Co. Ltd., Ilford	528
Potez, Société des Moteurs Henri, Paris	612
Radio-Industrie S.A., Paris	612
Radio Schweiz A.G., Berne	614
Richter S.A., Clichés, Geneva	616
Rohde & Schwarz, Munich	606
SAGAT, Turin	616
SARAM, Asnières	614
SFENA, Neuilly	610
SFR/CSF, Paris	546
SNCA du Nord, Châtillon	545
SNECMA, Paris	535
Sofrance S. A., Limoges	615
Southern Oxygen Co., New York	608
Standard Telephones & Cables Ltd., London	534
Sud-Aviation, Paris	518, 519, 520
Sylvania International, New York	550
Telefunken G.m.b.H., Berlin	529
Temco Export Corp., Washington, D.C.	603
Thomson-Houston, Paris	544
UAT, Paris	513
United Aircraft Export Corp., East Hartford	558, 559
Vertol Aircraft Co., Morton	538

Roughly 9 miles from the City centre
Runway 7,700 ft. long
Calvert approach lighting
G.C.A. - I.L.S. 3 - P.V.1B
24-channel radio link
24-hour service - Full repair equipment and service
Point of call for national and international airlines
Charter service - tourist service

aeroporto città di torino

SAGAT
S.p.A. 200.000,000
Head office Turin
S.Francesco d'Assisi 14
Tel. 528.626

Caselle Torinese Airport
Tel. 982.281 - 982.282
Cable address:
Aertorino-Caselle

Printed in Switzerland

TYPE 21 ADF
WEIGHS ONLY 19.7 POUNDS
Component Unit Weights:

Receiver, 6.8 lbs.; Loop, 4.3 lbs.,
Loop Housing, 0.5 lbs.; Indicator, 1.3 lbs.;
Control Unit, 1.6 lbs.; Power Unit, 5.2 lbs.;
CAA Certificate No. 1R 4-9

NEW LOOK in navigation aids

The Time Tested ADF Now In Less Weight, Less Space

The ADF is a basic air navigation instrument, used in all parts of the world, tunable to some 60,000 transmitters. But the important thing now about the ADF is that ARC has engineered an ADF system down to less than 20 pounds in weight, with a comparable saving in space.

Now pilots enjoy the advantages of dual installations of this compact miniaturized equipment in tolerable weight and space requirements.

The ARC Type 21 ADF is built to today's more critical speed and environmental demands. It has hermetic sealing of vital components, such as the entire loop assembly. It covers all frequencies from 190 kc to 1750 kc . . . operates on only 2.8 amps at 27.5 volts dc input. A significant feature is the extremely low loop drag — only two inches outside the aircraft skin.

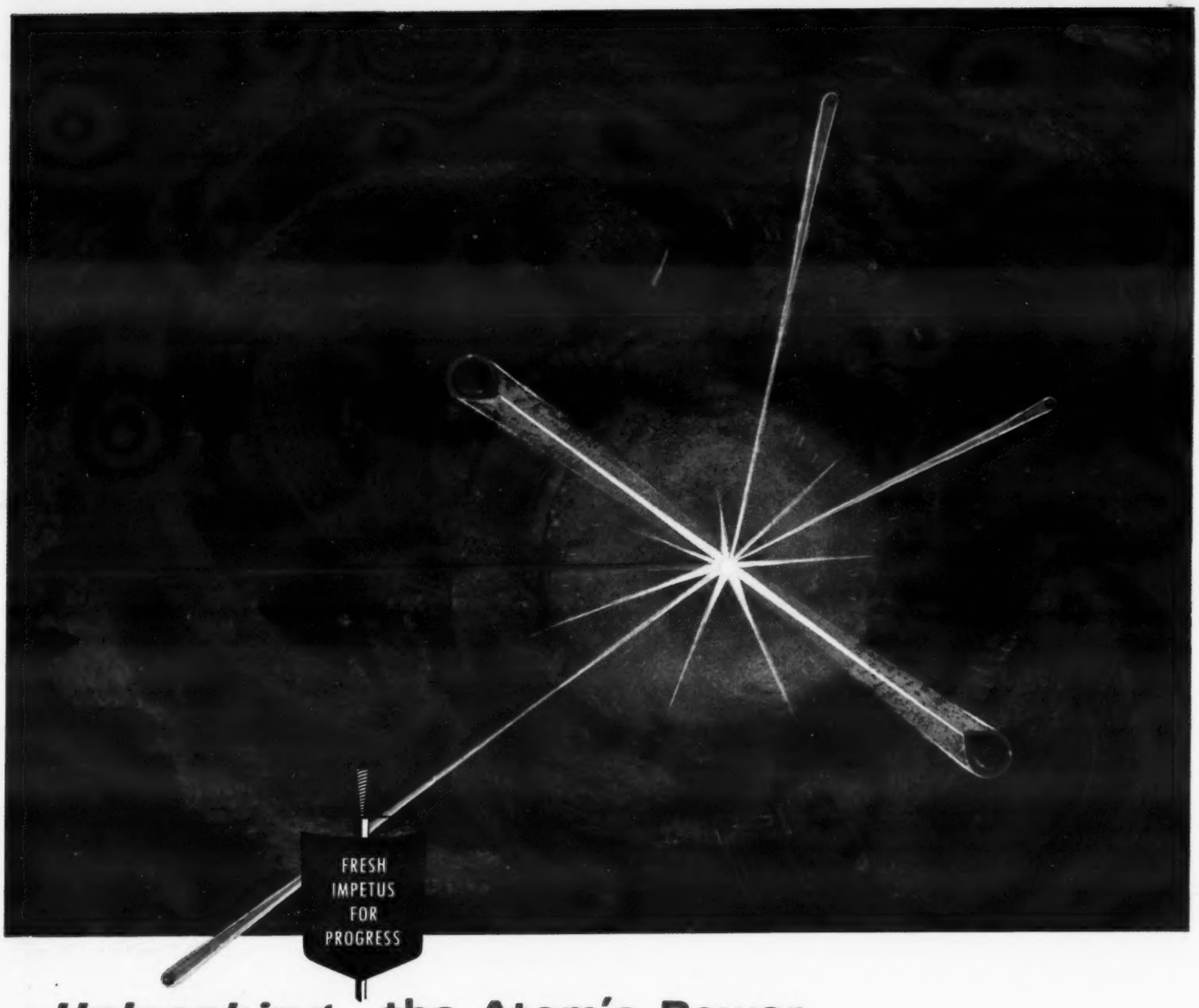
Ask your dealer for detailed literature.

Dependable Airborne Electronic Equipment Since 1928

Aircraft Radio Corporation BOONTON, NEW JERSEY, U.S.A.

Miniaturized Automatic Direction Finders
Omni/Loc. Receivers • Course Directors • UHF and VHF Receivers and Transmitters • LF Receivers
and Loop Direction Finders • 10-Channel Isolation Amplifiers • 8-Watt Audio Amplifiers • Interphone Amplifiers
Omnirange Signal Generators and Standard Course Checkers • 900-2100 Mc Signal Generators

Exclusive export representatives (except Canada): **Sterne, Carr and Farr Company, 425 Fourth Avenue, New York 16, N. Y., U. S. A., Cable Address: "Staraero"**



Unleashing the Atom's Power

Canadair has long been associated with the Government of Canada in the development of nuclear programmes. In its role of designer and builder of specialized research equipment, the company has successfully undertaken projects of considerable size and complexity . . . helping to unleash the atom's power for peace.

The experienced Canadair team of nuclear physicists is available for consultation with scientists or industries to study and specify how nuclear knowledge can be applied in any field: generation of heat and power—medicine—agriculture—metallurgy or general industry.

Inquiries are particularly invited from universities, laboratories and industries. Write to the Nuclear Division, Canadair Ltd., for the booklet: "Canadair in the Field of Nucleonics".

European Representative: J. H. Davis, Princes House, 190 Piccadilly, London, W. 1, England

CANADAIR

LIMITED, MONTREAL, CANADA

• Aircraft • Research and Development
• Guided Missiles • Nuclear Engineering

A SUBSIDIARY OF GENERAL DYNAMICS CORPORATION

CA57-UKT6